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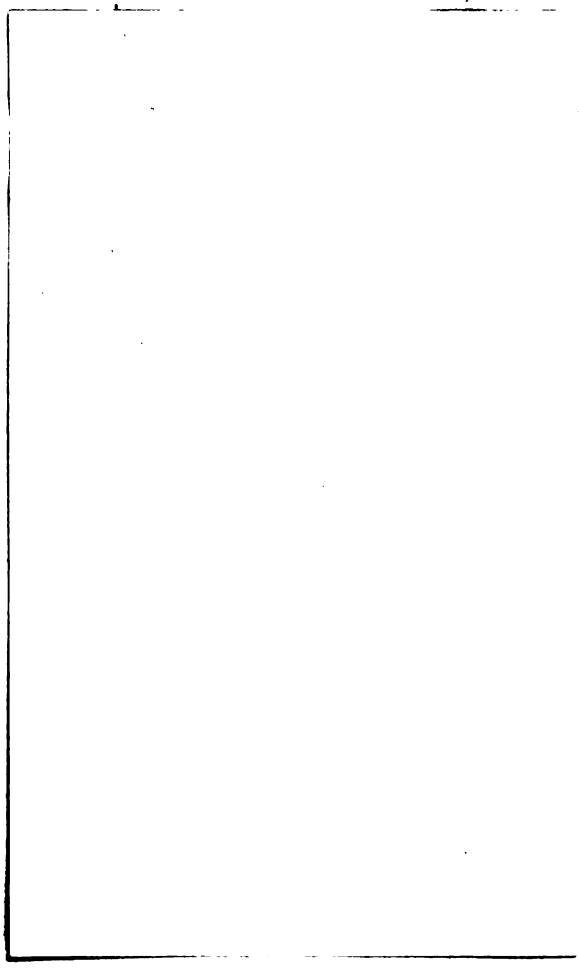

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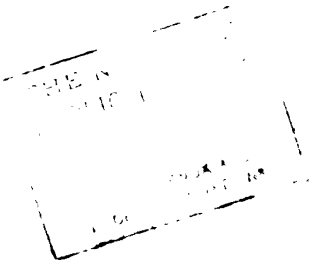

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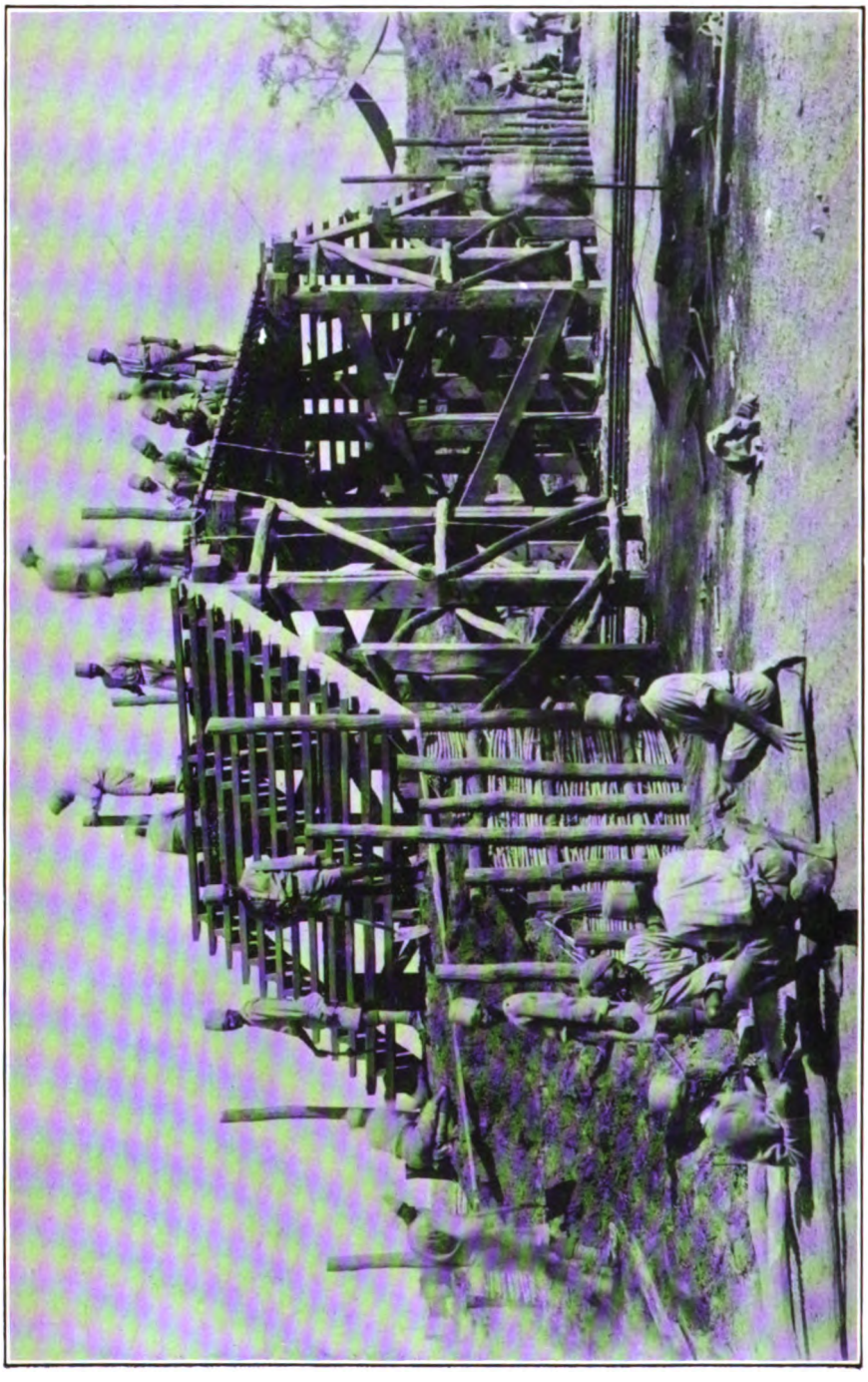

Bridge near rifle butts, constructed by No. 11 Co., 2nd Q.O. S. & M.

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DELHI DURBAR, 1911.

By the kindness of the Director-General of Military Works in India, we have been furnished with a series of reports of the Royal Engineer work done in connection with the Delhi Durbar of 1911. In the present number we print an account of that done by the 1st (K.G.O.) Sappers and Miners and by the 26th (Railway) Company, and we propose to reproduce the other reports from time to time in the Journal.

REPORT OF WORK DONE BY THE 1st K.G.O. SAPPERS AND MINERS.

The work done by this Corps may be conveniently classified under three main heads, viz. :—

A.—Work done by detached officers and companies.

B.—Work done by the Corps workshops.

C.—Work done by the Corps when assembled at Delhi from September 29th to December 24th, 1911.

A.—Work done by Detached Officers and Companies.

This consisted of survey work, the marking out of camps, reconnaissance and railway work.

The first requisition for work arrived on 11th January, 1911, when the Commandant was instructed to send a party of 1 British officer, 1 Indian officer and 36 rank and file to work under the A.Q.M.G. in marking out camps. This was followed a few days later by instructions to send two field companies for railway work under the Engineer-in-Chief, Durbar Railways.

Lieut. Hobart, with the party of 1 Indian officer and 36 rank and file referred to above, arrived in Delhi on 1st February. A 4-in. map was urgently required and since existing maps were not sufficiently accurate, an entirely new survey of the Durbar area was necessary. This comprised about 60 square miles.

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On completion of the survey, the work of marking out the camps for the civil authorities and Indian chiefs, as well as for the military, was commenced. The total number of camps so marked out was nearly 600. Owing to the failure of the monsoon the numbers of troops were reduced, but the camps were marked out originally for the full numbers, and the necessary modifications were made later.

The corners of the camps were first marked out with flags, which were afterwards replaced by brick pillars, aligned and located by theodolite. All roads and bridges were marked with tarred posts.

This party, with the assistance of three surveyors kindly lent by the Surveyor-General for three weeks, also prepared 16-in. plans of the different areas, on which the exact location and dimensions of all camps were shown. This was also done on the 4-in. map. These 16-in. plans were reproduced by the Corps Press, and the first eight editions of the 4-in. map by the Thomason College. The final edition of this map and its 2-in. reductions were prepared by the Survey of India Department at Calcutta.

On 14th May the party returned to Roorkee, but Lieut. Hobart was appointed Staff Captain and subsequently Officer in Charge of Fire Precautions, in addition to his military duties. On return to Delhi in September, the party continued to work under him on watering arrangements, the erection of signposts, and the laying out of work for pioneer regiments, etc.

In August two officers were ordered to Delhi to reconnoitre the roads between the Jumna and the Hindun, with a view to manœuvres taking place in this country, but these were, however, afterwards cancelled.

The 1st and 6th Companies arrived at Delhi on the 6th February, and were employed under the Chief Engineer, Durbar Railways, until the middle of May. The work consisted of constructing the Durbar Light Railway, for which the survey had been carried out by the Assistant Engineer, Durbar Light Railways.

These companies constructed the whole of the Polo Line, and the Amphitheatre Line up to and including the bridge over the Najafgarh Cut just beyond the station of that name.

In addition to several masonry culverts, two bridges, each of 44-ft. span, were constructed over the Najafgarh Cut, one alongside the Mall Road Bridge, and the other close to Najafgarh Station. These bridges were constructed of iron girders resting on masonry abutments and a central pile pier. The centre pier was constructed of eight piles, 20 ft. long and 10 in. diameter. The piles were driven about 10 ft. into the bed of the nullah and connected together by cross-bracing. Baulks 12 in. by 12 in. were fixed on

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top of the piles with $\frac{7}{8}$-in. iron dowels. These were laid over each pair of piles in a direction across the stream, two more 12-in. × 12-in. baulks parallel to the stream were laid across them 1 ft. apart for the girders to rest on. These baulks were also fixed with dowels. Each pair of girders had $\frac{3}{4}$-in. round iron ties fixed to the webs to prevent them spreading. The girders were 23 ft. long, with a clear span of 19 ft. 6 in. Eight girders were used, each truck resting on two girders. The roadway was carried by 64-lb. rails, 1 ft. apart, resting on the bottom flange of the girders, and C.I. sheets were laid over the rails. Stone ballast, and 6 in. of earth was then filled in between the girders.

As no pile driver was available ready made up, one was constructed of two 35-ft. 13-in. × 6-in. spars 1 ft. apart, resting on a 12-ft. × 12-in. × 12-in. baulk and stayed with 24-ft. L.M.R. rails. The monkey weighed 1 ton, and a winch was supplied by the railway for raising it. This, however, was not successful and the monkey was afterwards man-handled.

The pile driver having been placed in position, the pile, with four guys attached to it, was placed in its correct position under the monkey. The monkey was then given 1-ft. fall until the pile had sunk 2 or 3 ft., any direction from the vertical being corrected by the guys. Once the pile had been given a fair start in this way, 8-ft. to 10-ft. drops could be given and no difficulty was experienced in keeping the pile straight. Finally 6-ft. drops were given, and the pile was driven until six of these drove the pile about 3 in. only.

When the pier had been completed and cross-baulks and abutments carefully levelled off, the girders were slung into position by means of a 50-ft. derrick erected on one bank.

The bed of the nullah was generally soft but appeared to alter in accordance with the rise and fall of the Jumna.

It was found when making the second bridge near Najafgarh Station that the 20-ft. piles were not long enough and sank a considerable distance under the influence of their own weight, and when they had reached the necessary level, a 6-ft. drop drove them 2 to 3 in. 30-ft. piles were then ordered and arrived a week later. It was then found, however, that the bed had hardened and 20-ft. piles would probably have been sufficient. The 6th Company completed this bridge in a week after the arrival of the larger piles.

B.—Work of Headquarter Workshops.

As soon as the first programme of work at Delhi and the designs of bridges had been prepared, work was started in the shops. The bolts and nuts and dog spikes for all the Jumna and nullah bridges were made up, and these numbered in all nearly 5,000.

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Notice boards were made up for the A.Q.M.G. on payment, and a very large variety of small work of all sorts was turned out. This would be difficult to particularize. After the Corps had proceeded to Delhi the Shops also supplied several hundred pick, mamootie and axe helves for the use of pioneer regiments at Delhi, and also lent wheelbarrows, etc., for the work there.

On the 25th October orders were received for the supply of church furniture. This was all made and despatched at 7 p.m. on 5th December.

The Press did all the printing for the notice boards for the sign-posts at cross roads, prepared copies of the 16-in. map, and turned out a large variety of small printing orders. The greater part of the workshops out-turn for Delhi came from the temporary workshops which were established there in September.

C.—Work Carried Out by the Corps when Assembled at Delhi from 29. 9. 11 to 24. 12. 11.

In March, 1911, the Commandant discussed with the A.Q.M.G. at Delhi the nature and scope of the work to be done by the Corps for the Durbar.

It was then decided that the following bridges were required :—

Four bridges for infantry in fours over the Jumna.
Three bridges for infantry in fours over the Hindun.
Six bridges for infantry in fours over nullahs in camping area.

Two of the latter were to be capable of carrying an 8-ton steam road roller.

The Commandant divided up the work between company commanders, who prepared designs and estimates for the bridges allotted to them, and the work of purchasing and collecting material was started at once.

For the Jumna and nullah bridges 1,200 sleepers, 4,500 bullies, 500 42¼-lb. rails were collected by the N.W.R. at Chandrawal, where the field park was established. The sleepers and bullies were purchased locally. L.M.R. rails for use as roadbearers of the Jumna bridges were lent by the Corps and stacked at Wazirabad.

For the Hindun bridges 250 sleepers and 350 bullies were supplied from store at Roorkee and floated down the canal in rafts as far as Muradnagar. From here they were taken on country carts to the sites of the bridges at Sarora and Nekpur. All necessary bolts, nuts, dog spikes, etc., were made up in the instructional workshops at Roorkee.

In August, manœuvres were cancelled and the numbers of troops reduced. This did away with the necessity for Jumna and Hindun

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bridges and some of the nullah bridges, and the A.Q.M.G. prepared a new programme of work as follows :—

Three overhead bridges to take infantry in double column of fours.
Four 60-ft. fire observatories.
Four nullah bridges to take infantry in fours, one being capable of carrying 8-ton roller.
One bridge over Jumna below the fort for use of visitors to Badshah Mela.

This programme the Commandant accepted, and undertook to carry out the work with the funds previously allotted for the first programme.

The strength of the Corps at Delhi was as under :—

Headquarters and B Company.
No. 2 Company } from 29. 9. 11 to 24. 12. 11.
No. 6 Company }
No. 5 Company from 29. 9. 11 to 11. 10. 11 when they mobilized for the Mishmi Mission.
No. 4 Company less one section October 31st to 24. 12. 11.

In addition the 11th Company of 2nd Q.O. Sappers and Miners were detailed for work under the Commandant, and three sections arrived on 30. 9. 11.

Lieut. E. C. Whiteley was lent by the 3rd Sappers and Miners and was with the Corps during the whole time it was at Delhi. The services of Lieut. E. G. Kitchin were subsequently lent by the Director-General Military Works.

The heavy rains on the 26th, 27th and 28th September had flooded the camp already pitched by the advance party, causing some thousands of rupees worth of damage to the property of officers, Officers' Mess, and of the Corps.

On arrival on the 29th September the Corps had to pitch a new camp on the high ground near Dhairpur village, and until the 2nd October the men were employed in salvage work in the old camp and pitching tents and making roads in the new one.

On October 3rd the work of moving material from camp, from the Engineer Field Park and from the Coronation Durbar Power Station to the sites of the various works was commenced. Owing to the light railway having been flooded no trains were running, which retarded the collection of material. The Executive Engineer kindly placed one track of the line from Chandrawal out to the Amphitheatre at our disposal, and materials for all bridges adjacent to this line were man-handled on construction trollies along it.

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Materials for other bridges and observatories were moved in the Corps pontoon waggons, which had been sent down with pontoons and other stores by road.

The new programme of work as received in August, was being continually added to, and fresh demands kept coming in, even after the arrival of H.I.M. the King-Emperor.

The work eventually carried out was as follows :—

Overhead Bridges.

One over four tracks broad-gauge and two tracks light railway, length 150 ft., roadway 10 ft.

One over two tracks broad-gauge and two tracks light railway, length 70 ft., roadway 20 ft.

One over two light railway tracks, length 25 ft., roadway 20 ft.

One over two light railway tracks, length 25 ft., roadway 10 ft.

Nullah Bridges, Span 6 ft. to 120 ft.

Two to take infantry in fours.

Two to take infantry in fours in double column.

One to take 8-ton steam roller.

One to take foot passengers 5-ft. roadway.

Fire Observatories.

Four, one of which was given an outside staircase, necessitating considerable extra work.

Jumna Bridge.

This was required by the Mela Committee with a 16-ft. roadway, and, as pontoons did not lend themselves to this, a double bridge was constructed. This was washed away and a third bridge constructed.

Miscellaneous.

The Flagstaff Tower, which was used as an observatory, was provided with a roof.

Preparation of church parade site and furniture.

Erection of flagstaff in Amphitheatre.

Erection of signalling beacons and flagstaff on review ground.

Work in shops, and supply of materials and tools to pioneer regiments.

The trestles of the overhead bridges were rather heavier than necessary, but the design was necessitated by the materials available. For the bridges over the broad gauge the clearance from the centre of the track to the nearest obstruction was laid down by the railway authorities as 7 ft. The distance from centre to centre of tracks was 15 ft. 6 in., so only 1 ft. 6 in. remained spare for the trestles.

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It was thought at first that as the trestle between tracks could not be stayed in a direction at right angles to the tracks they might not be rigid and 1 ft. of concrete was rammed in round their feet. This, however, proved unnecessary, as the weight of the trestles and roadway was sufficient to ensure equilibrium.

The clearance from the top of the rails was 14 ft. 6 in. for the broad gauge and 12 ft. 6 in. for the light railway, but where bridges crossed both a clearance of 14 ft. 6 in. was given throughout. The trestles were first made up complete for each bridge and foundations prepared. The trestles were then all erected and temporarily fixed vertically in position with bullies spiked across the tops on each side between adjacent trestles, and earth was rammed in round the feet. This could be done without interfering with traffic, and it only took 10 to 15 minutes to get a trestle in position.

The roadbearers consisting of 24-ft. 41¼-lb. rails were then hauled up and bound in place with No. 14 gauge wire. To give rigidity the rails were bound together in pairs one with the top and the other with the bottom flange uppermost. The roadway was made of sawn sleepers, or, in the case of 10-ft. roadways, pontoon chesses. To save expenditure of sleepers where appearance was not of great importance, the lower flight of steps was made of earth revetted with gabion bands and grass, or split bamboos, *vide Photo* in *Frontispiece*.

The usual design for nullah bridges was that shown in *Photo* (Bridge S). The third bridge shown was used for the steam roller and was constructed with girders supplied by the railway authorities on piles already driven by them in anticipation of the light railway crossing this nullah. A sleeper deck was laid temporarily to take the roller across, as the roadway, which was 7 ft. without it, was not wide enough. The method of fixing the roadbearers, which consisted of L.M.R. rails, proved rapid and effective. The trestles were placed 11 ft. 2½ in. apart centre to centre so as to bring the fishplate holes at the ends of the rails opposite one another over any trestle. A ¾-in. iron rod was then placed through the fishplate holes and fixed down at each end with staples. To prevent any spreading, a few rails in each span were spiked to the transoms in addition.

The uprights of the fire observatories consisted of E.L. standards kindly lent by the Electrical Engineer, Durbar Installation, who also supplied all the necessary cross-bracing for them. The observatories had a flagstaff and electric light covered with red gauze for signalling the outbreak of fire. By day a red flag was run up and by night the lamp was switched on.

There were eight standards for each observatory and they were erected in pairs. In the first instance, after raising one pair, it was used as a derrick for lifting the three remaining pairs, but this was

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found unsatisfactory as it threw the original pair out of the vertical. Subsequent pairs were raised by a derrick. The derrick was then removed and each pair cross-braced. To carry the roof, bullies were fixed into the tops of the standards. The floor was laid on three pairs of sleepers laid across the top horizontal bracing, the centre pair being bolted to it.

Except in one instance, the staircases were erected inside the uprights. In the case where the staircase was made round the outside, the platforms were at the top of each length of the standard, and were supported on two iron brackets at right angles to one another clamped to the upright. This was only put up as a specimen, but was not approved. On completion, all iron and woodwork was painted white, except the outside of the roof which was painted brick-red.

Fear had been expressed by the Durbar Committee that these observatories would be unsightly, but when complete and painted they were far from being so.

Jumna Bridge.

The original demand was for a bridge with 10-ft. roadway, but the Secretary of the Badshah Mela stated that at least a 16-ft. roadway would be required.

Before starting the work the canal authorities were asked what would be the probable rise or fall of the river, and after consulting the records in their possession extending over 50 years, they stated that there was no chance of a rise, and that the river would fall 1 ft. 6 in. to 2 ft. before the date on which the bridge was required.

As funds were limited, a site was chosen giving the least span to be bridged. At this point the river ran in three channels one of which could be ignored as there was only 6 in. of water, the other two were 185 ft. and 77 ft. across respectively. This site was only feasible provided the river did not rise, and on the report of the canal authorities it was considered safe to ignore the possibility of this.

The materials available were 8 pontoons, 14 Weldon trestles, 60 15-ft. pontoon baulks, 12-ft. L.M.R. rails, 375 chesses and 10-ft. chair sleepers for the remainder of roadway. No. 14 gauge wire for lashings and sâl bullies in any numbers. As pontoons did not lend themselves to a 16-ft. roadway it was decided to make a double bridge of 10-ft. roadway over each span.

The work was given to No. 4 Company, consisting of three sections only, and they left camp for the site of the bridge on the 13th November, 1911. The bridge was completed over the two channels on the morning of the 22nd November and the company marched back to camp.

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Bridge S.—Constructed by No. 6 Co., 1st K.G.O. S. & M.

Steam Road Roller Bridge.—No. 2 Co., 1st K.G.O. S. & M.

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Just after the company started back information was received that the river was rising. The O.C. enquired at the canal office as to the cause of this and whether the rise was likely to continue. The canal authorities assured him that he need have no apprehension, as the rise would cease immediately. However, the river continued to rise for two days, the total rise being 3½ ft.

The flood, due apparently to an unprecedented fall of snow and rain in the hills, arrived too rapidly for demolition to be possible and the bridge had to be left. There was about 150 ft. of water between the ends of the bridges and the shore and about 2 ft. over portion of the bridges. In spite of this, owing no doubt to the weight of the rail roadbearers, the bridges stood.

Unfortunately the river did not fall as rapidly as it had risen. It started falling on the 25th November, but only fell at the rate of some 1½ in. a day. As the Durbar started on 7th December immediate action was required. So on 28th November, 1911, the company returned to camp by the river and started demolishing the four bridges. As the trestles had by this time sunk some 4 ft. or 6 ft. into the sandy river bed, and anchors were also buried deep, and the roadway some 2 ft. 6 in. under water, the demolishing was no easy task. The trestles had to be hauled out with tackle.

It was decided to build a new single-bridge 10-ft. roadway some half mile further down stream. Floatable material was floated down and heavy material carted. Owing to various detached parties, only some 70 men were available for work. The new bridge was started on the 1st of December and completed at 8 p.m. on 6th December, after which the company marched back 8 miles to their camp in the Durbar.

Accompanying sketches show section of bridge and type of trestle constructed.

Notes on Bridges.

Trestles.—This type of trestle was found very convenient. As the trestles never sank to the same depth in the shifting sandy bed, transoms had always to be adjusted afterwards. With the type of trestle used this was easily managed especially as care was taken that the transoms, before adjustment, were always higher than necessary. The difference in time and men required to lower or raise a transom is enormous, and if transoms cannot be fixed at the right height before launching it is as well to make sure that they are too high and not too low. Trestles sank on the average some 2 ft. into the sand.

Construction.—A 2-in. steel cable was erected as a flying bridge across the river some 50 ft. up stream. Building was carried on from both ends simultaneously. All trestles were floated out,

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being attached to the steel cable as in *Diagram* 4 on *Plate* and pulled out from opposite bank. When opposite their position, the trestles were floated down stream by letting out the rope passing through the block on the steel cable.

Two long spars were used as ways, with foot-ropes attached to the up-stream leg of last trestle in position as in *Diagram* 5 on *Plate*, one man on each way was able to keep them in position.

The trestle was then hauled up the ways some 5 ft. and two bights of a rope, fixed to a 3-in. rope passing to the opposite bridgehead, were thrown over the leg heads. A party on the opposite bridgehead then hauled the trestle up into a perpendicular position. This method saved an immense time as the trestles were too heavy to be easily pushed up by the usual method with hand rails.

Erection of Flagstaff in Amphitheatre.—This consisted of two spars of 90 ft. and the other 50 ft. in length. It had been sent up from Bombay by rail and the dockyard authorities also sent two 50-ft. spars and tackle for erecting it.

Lieut. Headlam, R.I.M., was responsible for its being correctly put up as regards all naval matters and had drawings showing the arrangement of foundations and rigging. This drawing showed the butt of the flagstaff resting on concrete foundations 10 ft. below the ground level. However, on reaching 4 ft. water began to appear and it was decided to reduce the depth of foundations, the excavation for which by means of a coffer dam of planks and use of a pump was carried to 6 ft. 10 in.

As there was no time to make alterations in the event of failure due to subsidence of foundations, and since the amount of ballast available was limited, the following arrangement for the foundations was adopted :—

Twenty-five bullies 6 ft. long were driven as piles in a square of 4-ft. sides, till flush with the bottom of the excavation and they were all carefully levelled.

Mauls were at first used for driving the bullies but these broke and a Norton tube with monkey and pipe was borrowed from the P.W.D. This saved all further trouble and the bullies were quickly driven. A sleeper platform 10 in. thick and 50 in. wide was then made up of sleepers bolted together. On the top of the platform chocks were fixed for the butt of the flagstaff to slide in between. Iron sheeting was screwed down between the chocks and well greased to prevent friction. This platform was placed on top of the piles, carefully centred and wedged in position with sleepers backed by concrete. Owing to the presence of water, cement concrete was mixed dry and put in in sand bags. A ramp was made down to the platform and the lower mast laid on the ground with

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its butt projecting over the ramp just short of the edge of the platform.

Foot-ropes, etc., were attached, and the mast raised, the head being first raised with a 30-ft. derrick, and the strain was then taken on sheers and the mast raised to the vertical. The foot-ropes were let out as required and the mast slid into its position on the platform without any trouble. The advantage of the form of foundation adopted was that once the mast was erected it was in its correct position and required no subsequent shifting. The top mast was raised in the usual manner with tackle rigged to the lower mast. Some delay occurred in this, as the men working at the top of the lower mast, not being used to the work, allowed the lifting rope to get out of the grooves, thus causing a jam. However this was righted and the rigging was finished off to the satisfaction of Lieut. Headlam.

Erection of Signalling Beacons and Flagstaff, Review Ground.—For use at the Review to ensure all troops acting together, the A.Q.M.G. asked for a ball 6 ft. in diameter that could be raised or lowered at will, to be erected where it could be seen by all troops on parade. The ball was made up of a frame of split bamboos with an iron rod through the centre and canvas sewn on the outside, the whole being painted black. An E.L. standard was borrowed from the Electrical Engineer and fitted with a bracket at the top, 4 ft. in length, and was erected in rear of the pavilion post. It was tested at the rehearsal and worked well. The authorities were, however, afraid of failure, and a second was asked for and erected, but was not used.

Flagstaff.—The flagstaff provided for use was 40 ft. in length, and in three pieces, most of the joints being loose. As the appearance of this flagstaff was not very satisfactory, permission was asked to erect a flagstaff consisting of an E.L. standard with the top of the mast let into it. This was obtained, the standard was painted with white ripolin, and the iron fittings and the truck gilded. Half-inch wire rope guys were fitted with screw-tightening shackles fastened to chains attached to buried holdfasts. This gave a flagstaff over 50 ft. high which was the minimum height possible to carry the silk Royal standard provided for the occasion.

An unfortunate accident occurred owing to the sheaf of the truck breaking just as the King-Emperor arrived, and this caused some delay in breaking the standard.

Church Parade.—The ground for the church parade was marked out, and profiles of the various banks made. The actual earthwork was done by the pioneers. Arrangements for the supply of bricks and bajri for the paths were kindly made by the Garrison Engineer, Delhi. All the furniture was made up in the Roorkee workshops.

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Workshops at Delhi.—Work in these was carried out under the Superintendent of Instruction.

The work for the Durbar consisted chiefly in making signboards, map boards, beacons, etc., and the following is an approximate list of the work carried out :—

200 Signboards.
250 Notice boards.
80 Map boards.
500 Small boards with names of regiments, etc., painted on them.
8 25-ft. beacons for Review ground.
2 Signalling beacons for Review ground.
1 Flagstaff for Review ground.

In addition several small jobs in connection with the bridges were carried out, whilst the supply of materials and tools for pioneer regiments was arranged for. In addition to the above it was found possible to carry out a good deal of private work, such as shoeing, repairs to traps and minor repairs of all kinds for officers of different regiments at Delhi.

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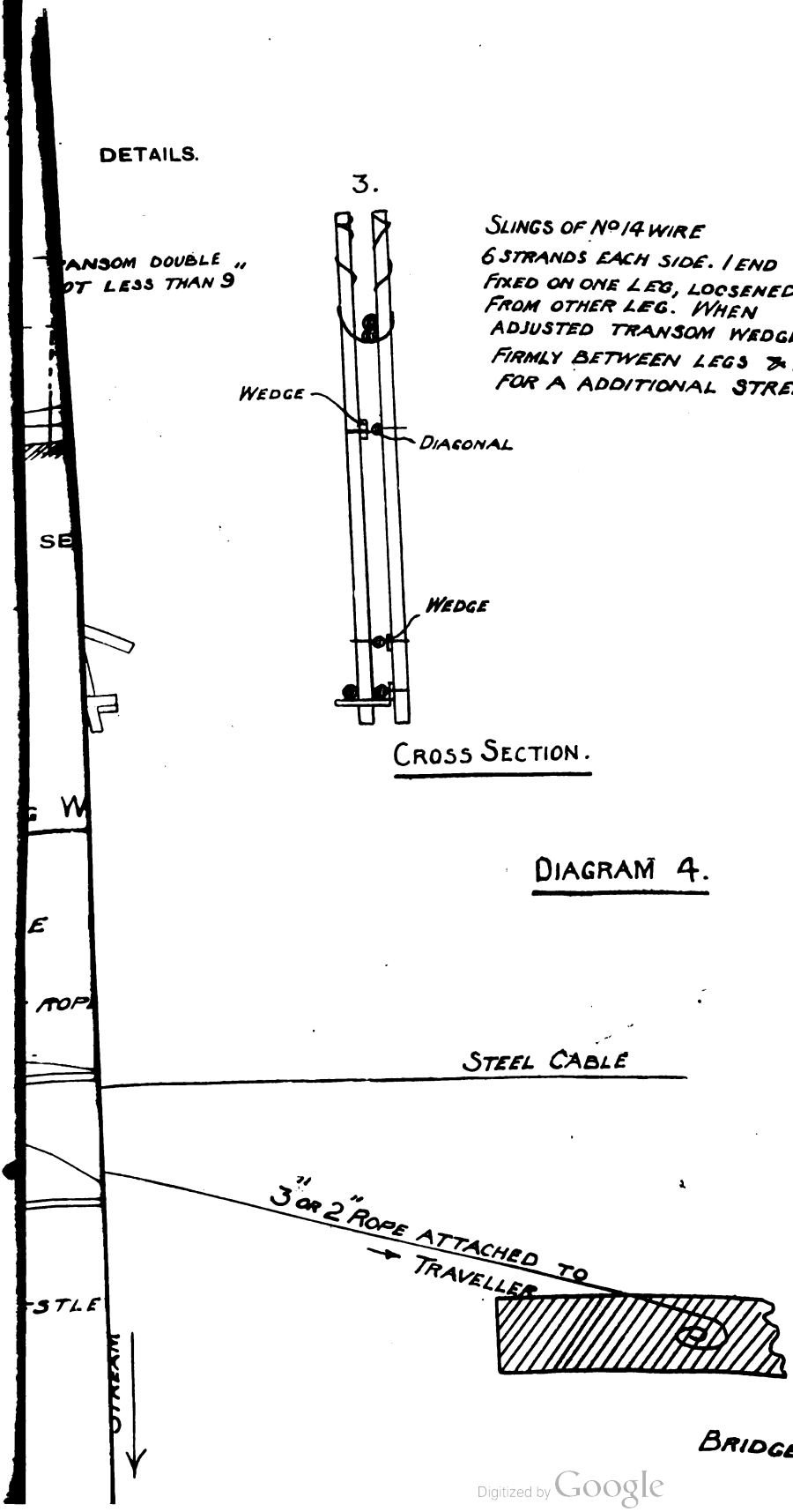
DETAILS.

3.

SLINGS OF No 14 WIRE
6 STRANDS EACH SIDE. 1 END
FIXED ON ONE LEG, LOOSENED
FROM OTHER LEG. WHEN
ADJUSTED TRANSOM WEDGED
FIRMLY BETWEEN LEGS & WIRE
FOR A ADDITIONAL STRENGTH

CROSS SECTION.

DIAGRAM 4.



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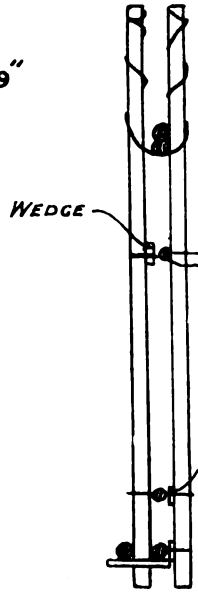

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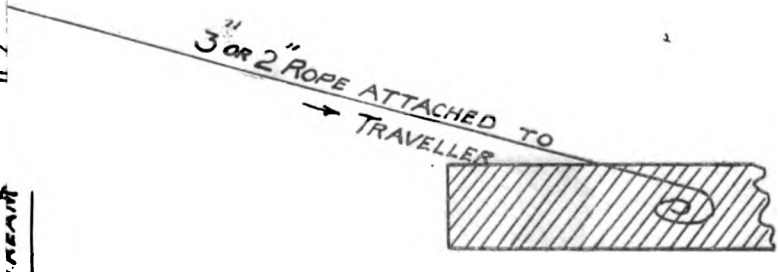

BRIDGE HEAD

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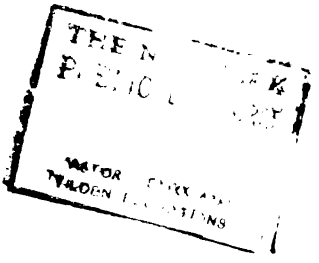

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THE WORK DONE BY THE 26th (RAILWAY) COMPANY, S. & M., ON THE DELHI DURBAR RAILWAY, 1911–12.

By LIEUT. G. D. RHODES, R.E.

THE 26th and 25th (Railway) Companies, S. & M., are permanently employed by the N.W. Railway. The 26th Company has been employed on the maintenance of the Sialkote-Jammu branch since 1909. This branch had previously been maintained by the 25th Company.

Preliminary.—The order to proceed to Delhi was telegraphic and was received on 13. 5. 11. The only previous intimation which had been received was a letter from the Engineer-in-Chief, Delhi Durbar Railways, asking whether the company could arrive by the 1st September. Acting on this information, men were sent on furlough at once, and arrangements to begin musketry made. Engineer-in-Chief's telegram upset all these arrangements (except furlough, which was not cancelled, being one year overdue). A little difficulty arose on the eve of departure owing to the management of the railway not having informed the G.O.C., 2nd Division, of the intended move. The company was ordered to stand fast by the G.O.C., Sialkote Brigade. The required permission to proceed was received after an exchange of long wires at 20 hours on 26. 5. 11.

The Sialkote-Jammu branch had not been run by civilian labour since 1902, but in spite of this and the fact that it was the harvesting season, the men were replaced by civilian labour throughout, all works were measured up to date, and the sub-division was handed over on 20. 5. 11.

The men were allowed on leave in big batches in order to settle their home affairs and the company was ready to depart on the evening of the 25th.

No information as to camp site, or even situation was furnished beforehand, in spite of several telegrams, so that an advance party could not be sent. Neither was the O.C. informed as to the nature of the work to be done beyond the fact that the company was to be employed on contract.

The move was easy, as a special mixed train was put at our disposal

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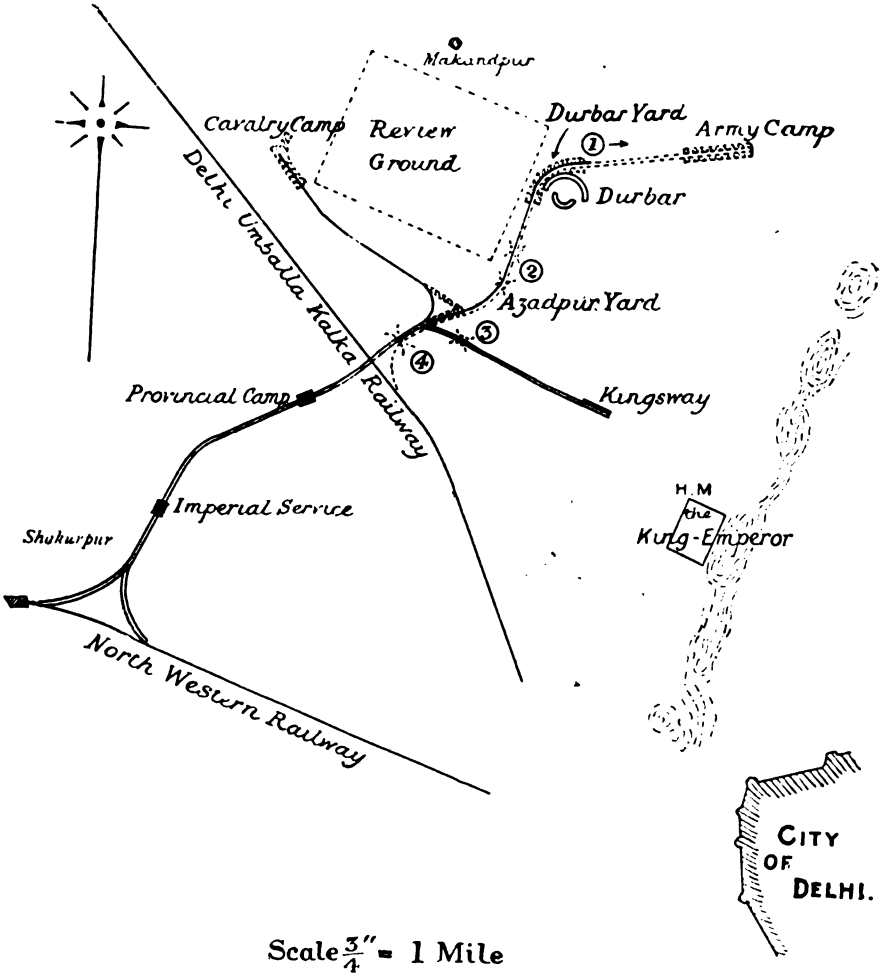
24 hours before the time of departure. The company was thus enabled to load the train the day before. All stores and tools and plant were taken to Delhi as it appeared unlikely that the company would return to Sialkote, the annual relief taking place in the next trooping season.

The company entrained at 9.30 a.m. on 27. 5. 11; arrived, and were detrained, at the site of their future camp at 6 a.m. on 28. 5. 11, strength: O.C., Lieut. Fraustadt, R.E.; 1 B.N.C.O.; 2 N.O.'s; 1 doctor; 165 rank & file. They were met by Mr. Lyle and Mr. Owen, under whose orders they were to work. The journey down was enlivened by a fire in an open truck full of charpoys, etc., which was promptly dealt with.

DELHI DURBAR RAILWAY, 1911, ON MAY 30TH.



Scale $\frac{3}{4}$" = 1 Mile

WORK DONE BY 26TH (RAILWAY) COMPANY SHOWN DOTTED.

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Camp.—The site of the camp was excellent in all respects but one. It was impossible to drain it really satisfactorily. It had previously been occupied by the 128th Pioneers. The water supply (well) was plentiful and excellent, and remained so throughout the hot weather. The men were first housed in the mobilization shouldaris but after a week I.P. tents were received. A latrine of 14 seats was built of C.I. sheets, old C.I. cot planks and sleepers; and a circular incinerator of brick with an iron fireplace in the centre. This worked very satisfactorily. A "chappa" shed was built as a stable. Altogether the camp was very comfortable. Some difficulties about supplies was experienced at first, owing to the S. & T. refusing transport on the ground that the company was "on contract."

Work.—Work was started on 30. 5. 11, and up to 1. 11. 11 it consisted of:—

Construction of Line.—The map on preceding page shows the lines laid by the company. As stated above the company was working under Mr. Owen, who was Executive Engineer of the part of the Delhi Durbar Railway north-east of the Delhi Umballa Kalka Railway. All yards were laid by the company except Kingsway.

The Sepoys were organized in 12 gangs of about 14 men in each, tradesmen excluded. The coolies in gangs averaging 15 strong, each under a lance-naik. When linking, the disposal was roughly as follows:—

Coolies unloading and spreading sleepers	30
Coolies unloading and spreading keys, chairs and spikes ..	10
Sepoys unloading and spreading rails	15
Carpenters punching auger marks	6
Augerers	20
Hammermen	12
Linking	12
Spannermen	6
Keymen	32
Total ..	153

These figures are approximate and include only "workers." N.C.O.'s are not in the count. The proportions varied from day to day according to the lead, disposition of load on ballast train, whether railhead or doubling, etc. Gangs were changed round about once a week. Working hours were 6 to 12 hours and 17 to 19 hours—8 hours in all.

Saturday evenings were spent in drill and every alternate Sunday was a holiday. The men proceeded to and from work in the ballast train when available. Parade before work was in camp and dismissal from work at site.

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About 10 miles of line have been laid. The work commenced at (1) (see map). Army Camp was completed first in rather a hurry, as the Irrigation Department wished to close their bund (built to restrain the expected flood of the Jumna, which never came) which crossed the line right across what was afterwards Durbar Yard.

The line was then doubled from Azadpur to Durbar, except the Azadpur end where a diamond crossing was awaited for over two months. Durbar Yard was next completed as far as the bund allowed. The scene of work then shifted to Cavalry Camp, which was completed by the 10th of September, after a great deal of trouble with the "island lines," owing to the platforms having been built first at an angle slightly wrong. Nearly 20 days were spent slewing the lines here and there trying to make them fit into the platforms; but finally the platforms had to be moved. The extraordinary plan of the yard was due to the intended Mokundpur line, which was never built. The work throughout was never continuous but proceeded as material arrived, the men being in the meantime "employed as requisite."

The majority of line was 73-lb. B.H. rail on 40-lb. chairs and wooden sleepers. The remainder was made up of (about 2 miles) 73-lb. B.H. rail on 45-lb. chairs and wooden sleepers; (about 1½ miles) 68-lb. B.H. rail on 40-lb. chairs and wooden sleepers; (some) 62-lb. F.F. rail on steel sleepers; (some) 87-lb. F.F. rail on wooden sleepers; (some) 75-lb. F.F. rail on wooden sleepers.

Sleepers Used.—Deodar, new; deodar, S.S. (some very bad); jarrah wood, new; jarrah wood, S.S.

Crossings.—Majority were 75-lb. F.F. 1 : 8½ and 1 : 12. Remainder 75-lb. D.H. block, 1 : 10; 60-lb. D.H. block, 1 : 10 (for which a little D.H. rail had to be used); 90-lb. F.F. 1 : 8½.

Check rails and blocks were 75-lb. F.F. The greatest difficulty met with was to keep the gauge accurate. The great variety of material (at first 40-lb. and 45-lb. chairs were mixed up together) prevented the provision of the "Box" form of template. This is a template *through* which the sleeper is bored. It holds the auger perpendicular and is, of course, accurate. Sufficient templates of this kind could not be made to keep 20 augers employed, for each different kind of chair and sleeper. The method of laying by which one rail is laid first and then the other to gauge, was rejected as being far too slow. The method adopted was to make a board template, the under side of which was covered with metal. Through this the carpenters made punch centre marks for the guidance of the augers and marked the centre of the sleeper. It was not an accurate method as the auger was not held perpendicular, and so the spikes drove the chairs in or out. Another source of inaccuracy was the fact that the 45-lb. chairs are too big for the 73-lb. rail.

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A great deal of re-gauging had to be done when the lines were finally packed up. The error was from "plus" $\frac{3}{8}$ in. to "minus" the same, the majority (especially with the jarrah wood) being on the tight side.

The average rate of laying completed track (including unloading) when all material fitted, was 5 lengths per hour. The maximum at railhead 57 lengths in 8 hours. The maximum when doubling, 88 lengths in 8 hours (a length is 30 ft. and there are 12 sleepers to a length of 73-lb. chaired road).

It was found:—(i.). That it was more economical to spike the chairs on to sleepers after spreading because two men can double with a "light" sleeper; three men cannot double with a loaded sleeper.

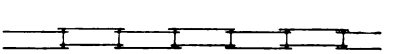
(ii.). That it took 12 men to lift a 30-ft. 73-lb. rail comfortably and handle it smartly. These men were made to work to a whistle.

(iii.). That it was more economical to carry material straight to its place than to make use of trollies. (Note, only five trollies were available, ballast trains were more often than not, loaded in the wrong order, there were no shunting facilities within reach, and the lead was never more than 650 yards).

(iv.). That it was best for spanner men to work in pairs, with one crowbar between three pairs, and for keymen to work in threes—1 hammer, 1 tommy, 1 crowbar.

Bridge Erection.—The overbridge at Azadpur, (4) on map, was entirely the work of the company. At (2) small girders were placed in position. These were only 12-ft. girders. At three (3), 10-ft. square trough girders were put in.

The construction of the overbridge at Azadpur consisted of a double 11-ft. roadway, carried on four Warren girders of 60-ft. span. The road transomes were 11-in. × 5-in. **I** girders strengthened by 3-in. × 3-in. angle iron. Triangular struts were bolted to the top of the road transomes and under the top flange for transverse stiffness; longitudinal stiffness being given by angle-iron bracing under the transomes. The floor is made of six rows of sleepers on edge, bolted to their ends so:—



These were then covered with kunker placed on 14-gauge C.I. sheeting.

Work was carried on intermittently on the cribs as material arrived. The first girder took 10 hours in erecting, and the last only four.

The main cribs were bolted right down the four corners and were constructed of new deodar sleepers. These were bored with a template and threaded on to the bolts from above. Owing to the

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number of intermediate sleepers (three sleepers touching each other) a good deal of adzing was necessary to get an even bearing. This spoils the sleepers for future use as such, but packing pieces were inadmissible. The crib building was in charge of Sergt. Butt, R.E.

Two 40-ft., 12-in. square, derricks were employed for lifting the girders. The main lifting tackle consisted of 5-in. rope, two quadruple blocks and a snatch block. The side guys were doubled 3-in. rope. The fore and back guys were compound, *i.e.* the portion attached to the derrick was a doubled piece of 4-in. To this was attached on the fore guy, a single and double tackle 3 in.; to the back, a double and treble tackle 3 in. The 4-in. was doubled to save cutting. The tackle was varied because it was all that was available. Tackle was put into the guys because the girder had to be lifted up the side of the crib with the derrick straight, and then put on to its bearings by leaning the derrick over. Holdfasts were made of sleepers sunk 6 ft. into the ground and were of the 2 : 1 type.

The whole strength of the company was employed for lifting, more for instruction than from necessity.

The method adopted was as follows :—The standards having been erected the derricks were allowed to rest against the embankment. The girders were then crowbared from their position parallel to the railway lines, to a position across them and as close as possible to the crib (see *Plate, Sketch* 1).

The derricks were next raised and the girder made to stand on the bottom chord. The girder having been "scotched" into its new position, the derricks were again moved closer. The girders were then lifted into position. The total lift was 24 ft., and when in position the bottom chord is 16 ft. 6 in. from rail level.

The only difficulties met with were :—

(i.). The appalling ignorance of the men. About 1 per cent. only had any knowledge of knotting, and all were frightened of a rope when loose and absolutely callous of holding the same when the weight was on it.

(ii.). With the first girder. Four cribs having been built to get the distance pieces in, No. 1 Girder had, of course, to be lifted from the outside. The derricks could not "lean" and had to be lifted with difficulty off cribs. Once got standing they were left so. So that the girder had to be got past two pairs of cribs and then between the derricks and the cribs (see *Plate, Sketch* 2).

(iii.). When the girder was not hanging quite plumb, it was found that if the top flange was allowed to take its bearing and the bottom chord then levered into its "clip," the top had a most disconcerting habit of coming off sideways, throwing the weight on to the tackle again. Experience showed that it was advisable to get the bottom chord home first and then lower on to the bearing.

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(iv.). The age of the girders. They arrived in three pieces each and were bolted together at site in the ground. The bolts did not hold the top flange sideways and the consequence was that, when in position after lifting, the flange in every case exhibited a reverse curve. They straightened out, however, when the road transomes were put in. The girders, it is understood, have been on the scrap heap for 20 years. In their prime they carried broad-gauge engines.

The other two bridges were simple and were merely a case of 15 minutes man-handling in the case of the 12-ft. girders, and of four hours in the case of the troughs, which were much more awkward to handle.

Maintenance.—In the beginning of September the company took over the maintenance of the whole of No. 2 Section of the D.D.R. This arrangement proved unsatisfactory owing to civilian supervision, and on the 20th the portion Azadpur-Army Camp was taken over by the company, the remainder being handed over to civilian labour.

The rain at the end of September did a great deal of damage to the line, washing out the bank under the down line between Azadpur and Durbar.

The bund was finally breached on the 8th October and the up line was passed for passenger traffic on 13. 10. 11. The down line was ready for traffic from Azadpur to Durbar on 16. 10. 11. By the end of October the line was doubled between Army Camp and Durbar, and only one crossing remained to be put in in Durbar Yard. This work presented no points of special interest.

Reorganization.—To ensure efficient supervision, the company was now slightly reorganized, so that the organization for work became the same as the military organization. The company was divided into four sections, each under a havildar, and each section again was further divided into two or three squads, each under a naik. Each jemadar was placed in charge of two sections. The line similarly, was divided into four distinct sections, as follows :—

(1). Azadpur to Durbar (exclusive).
(2). Durbar Yard.
(3). Durbar to Army Camp (both exclusive).
(4). Army Camp Yard.

Each section (company) consisted of 35—40 men, and each section of the line contained about 400 lengths, *i.e.* approximately 2⅓ miles.

The result of the above was that each N.C.O. always had the same men under him, both during work and on drill parade, and each was made to realize that the efficiency of the particular part of

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the line of which he was in charge depended entirely upon the efficiency and good work of his own section. Under these conditions, the work of the men steadily improved.

Maintenance work was continued throughout the Durbar period, without a hitch or accident of any kind. In fact a compliment was paid the company by the Traffic Department asking them to assist in regulating the traffic on Durbar day, and also on the days of the Review and Military Tournament, as the ordinary open-line coolie was not sufficiently to be depended upon.

The men took part officially in no parade during the Durbar, but owing to the kindness of General Cox and Sir John Hewitt seats were allotted to the company both in the Amphitheatre and at the Review.

The Native officers, however, were presented to H.I.M. the King-Emperor by the O.C. on the occasion of the presentation of all the N.O.'s in Delhi.

Dismantling.—During the first week in January practically all the civilian coolie labour was dismissed, the company took over the Cavalry Camp line as well for dismantling, and the O.C. was appointed temporarily as S.D.O., Azadpur.

Within a fortnight all the station buildings, fencing, watering arrangements, and as much as possible of the lines to Army and Cavalry Camp had been pulled up, the material being placed close to the line remaining.

In dismantling the 12-ft. × 12-ft. × 4-ft. water tanks, which were placed on 20-ft.—25-ft. crib piers, three 30-ft. rails were used, and the tanks were pulled over on to these by tackle and slid down.

The remaining period was used to load material as wagons became available. The sidings were dismantled in Army Camp and Cavalry Camp but the work was greatly delayed owing to the scarcity of wagons and trucks.

Miscellaneous.—During the latter period those men to whom furlough was due were allowed to go as furlough was a year overdue. Casual leave too, has been granted as much as possible, as practically no leave was granted previous to the Durbar.

Latterly a section at a time has been withdrawn altogether for a day, for instruction in knotting and lashing, and it was found that very few of the men knew anything at all about it, though the majority of the N.C.O.'s could be relied upon to tie the commoner knots.

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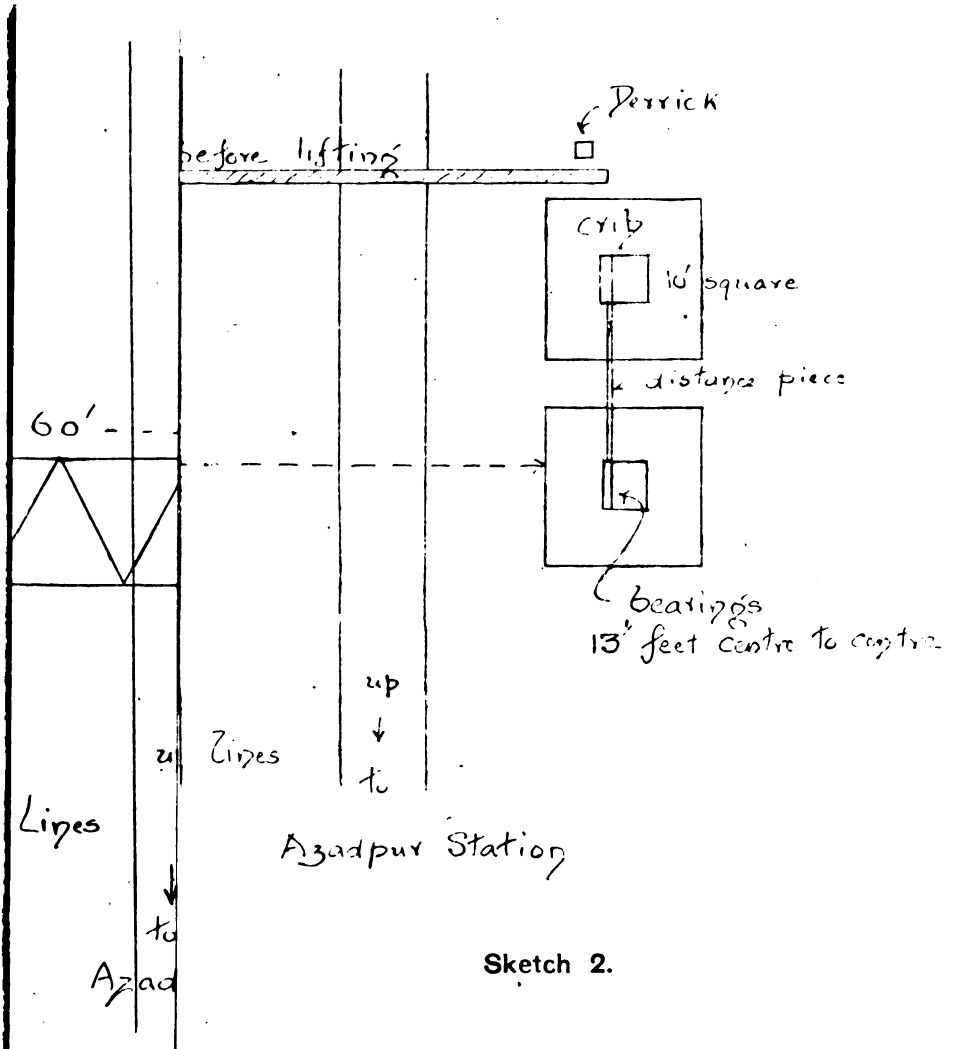

Sketch 2.

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IE BY THE 26th (RLY.) COMPANY, S. & M.,

in. through HE DELHI DURBAR RAILWAY, 1911-12.

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THE EMPLOYMENT OF R.E. IN WOOD FIGHTING.

By CAPT. W. G. S. DOBBIE, R.E.

IN an article in the August, 1913, number of the *R.E. Journal* on the subject of operations in woods, an attempt was made to discuss the bearing of woods on the tactics of infantry and artillery. But very little was said about the work of the R.E. in connection with wood fighting. It seems to be a reasonable assumption that woods will be more important tactically in the future than in the past. Many factors contribute towards this end, notably the introduction of aircraft and the consequent necessity for troops to conceal themselves in woods, villages and other similar localities. In the August article the paramount importance was shown of training the infantry in peace time in this sort of fighting, as in many respects it differs from other kinds of fighting and imposes a very great strain on the nerves of those who are unaccustomed to it. It falls to the lot of the R.E. to help on the infantry over difficulties of terrain, and it therefore behoves us to give the question careful consideration, so that we may be able to find out and practise the best means by which we can do so. It is a subject which needs to be carefully studied, as the light of nature will not tell us what to do, and it is a subject which perhaps repays study more than most.

It is proposed to deal with the work of the R.E. first in attack and then in defence. And before we can settle the best manner in which the R.E. can help the infantry in the various phases of the action, it will be necessary to remind ourselves of the special characteristics of the particular phase that we are considering.

Attack against the Front Edge.—In this phase the action will be of much the same nature as in any other part of the battlefield, except that the attacking infantry will probably have a more distinct objective than usual, viz. the edge of the wood. The artillery of the attack will also be able, in most cases, to support the infantry with greater effect than usual, as the defence may not be able to bring much artillery fire against the ground in front of the wood. These remarks are, of course, very general, but the tendency will be for the attack to make ground to the front more quickly than usual. The work of the R.E. in this phase will be much the same as in any other attack, but the R.E. must be well up, and in considerable numbers, as they will be needed as soon as the front edge is carried. Not only a few men with cutting tools, such as very often accompany an infantry attack, but the bulk of the R.E. company that happens to be on the spot. In the event of the Brigadier (or the officer directing the attack) forgetting to send up the R.E., it will be the

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duty of the senior R.E. officer to remind him of the importance of the R.E. being well up during the attack. In the case of divisional headquarters, when orders for the attack of a wood are being got out, the C.R.E. should see that R.E. are detailed to accompany the attacking troops. It is difficult to lay down any definite proportion of R.E. to infantry in these circumstances, but it may be taken as a rough guide that the *absolute minimum* is one field company to a brigade or one section to a battalion.

Fight inside the Wood.—In the attack on a wood, history shows that the real danger to the attacking troops occurs, not during the advance against the edge of the wood, but after the edge has been gained and the troops penetrate inside the wood. The passage through an unknown wood always causes confusion, and the defenders have excellent opportunities of making vigorous counter-attacks with the bayonet, and of driving the attackers out of the wood again. Time after time has this occurred, and numerous instances of this phenomenon were cited in the August article. The effect of these counter-attacks has been out of all proportion to the numbers employed, for the simple reason that they come as a surprise. Here then is a matter in which the infantry need help, and it is up to the R.E. to provide it. Let us briefly review the situation. The attacking infantry have succeeded in gaining the edge, and although they may not have encountered very severe opposition, they are bound to be in considerable confusion. The artillery which has so ably helped on the attack can no longer assist, and the infantry feel that they are now left to their own resources. The enemy, who held the edge, has withdrawn into the interior of the wood. The trees prevent our troops knowing what forces of the enemy may still be lurking in the interior. The enemy knows his way about the wood, our troops do not. Everything in fact combines to make the men jumpy and to see dangers where none exist, and this is one of the reasons why the counter-attacks referred to above produce such surprising results. If the infantry could see some slight obstacle of breastwork between themselves and their invisible foe their nerves would be very much steadied. They cannot make it for themselves, as they carry very few cutting tools, and as they are busy reorganizing. It is here that the R.E. can help. Some slight breastwork should be made just inside the wood, *directly* the edge is captured. This breastwork need not be bullet proof, as the bayonet and not the firearm is the weapon for the interior of a wood. The breastwork need not be elaborate, so long as it provides a slight obstacle to the progress of a counter-attack. Its effect is intended to be moral rather than physical—and speed in its construction is of more value than an elaborate design. This is a thing that might well be practised with infantry in any station where government woods exist. The details must be adapted to suit the various kinds of wood. In some cases branches should be cut down

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to form a rough abattis. In others, trees should be felled. In the latter case should explosives be used or not? If so they must be carried by hand during the attack, perhaps in the form of ready-made necklaces. The tool carts with more explosive, or the pack animals, will have to be rushed up as soon as possible, as more explosive will have to be used during the passage through the wood. There are here innumerable little points that will have to be thought out, discussed, and actually tried, as the conclusions arrived at by experience are always much more valuable than those gained by theory.

The Fighting in the Wood.—The characteristics of the fighting in the wood are that the defenders will endeavour by numerous small counter-attacks to drive the enemy out again. There are many instances in history of attacking troops forcing their way almost to the far side of a wood, and then being counter-attacked and driven right back again. It seems to be very difficult to rally the troops if they are being driven back by a counter-attack, and anything that the R.E. can do to help to check the retirement will be of value. General Clery in his *Minor Tactics* points out how extremely important it is for troops working through a wood to keep some formed bodies, however small, at hand so as to check the counter-attacks. These small bodies will be the better able to carry out their functions if they are provided with some slight protection of the same kind as that mentioned above. It will fall to the lot of the R.E. to provide this protection and form little rallying points at different places in the wood, behind which the troops could rally in the event of their being pushed back by the enemy's counter-attack. It is not contemplated that these rallying points should be capable of an obstinate and protracted defence. For one thing it is not likely that their flanks could be secured, nor that the enemy could be prevented from working round the flank. But they are intended simply to gain sufficient time for the retiring infantry to pull themselves together preparatory to renewing the advance. The moral support of such works will be great if the advancing infantry know that close behind them there is some shelter however flimsy.

The best methods of preparing these rallying points will need to be carefully studied as well as their size. Probably this latter will not be very great, as there will rarely be much time in which to do the work, and they will be most effective if they are small and fairly numerous. If this is so the R.E. must be split up into several small bodies, so that they may be able to construct several of these posts at the same time.

Again, to refer to the lessons of history; all the records of wood fighting prove how very tenaciously a small force may hold on to the interior of a wood, and how very difficult it is for the attackers to clear the wood of the defenders. The latter, presumably, know their way about the wood better than the attackers, and will be able to turn this local knowledge to good account. In order then to occupy a wood, it will be necessary to make good each part

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systematically. For this purpose the defensive posts referred to above should prove most useful, and so their construction would be doubly justified, as they would, so to speak, be killing two birds with one stone.

Debouching from the Wood.—Very often the main defensive line will be behind a wood, especially in that part of the field where the defenders do not intend to take the offensive. It may therefore be necessary for the attackers to debouch from the wood for the attack of the main position. The French position about Elsasshausen at the Battle of Worth was an instance of this. Debouching from a wood under these circumstances is an extremely difficult operation, as generally all the advantages of artillery support will lie with the defenders. How best can the R.E. help here? In the first place, the far edge of the wood may be entangled and observation mines may be encountered at places where the attackers are likely to congregate. The discovery and removal of these will fall to the lot of the R.E. In this connection it must be remembered that if the enemy have placed one mine in a certain locality, they have probably placed several, and a thorough search will have to be made for them before the infantry attempt to mass near the edge. The infantry will be in considerable confusion after their passage of the wood, and before the advance is continued it will be absolutely necessary to reorganize. It is suggested that this reorganization take place at a little distance from the edge, inside the wood, and that while it is going on the R.E. should be searching for the mines, and removing the entanglements so far as they can.

In order that the infantry may debouch from the wood, it will generally be necessary for them to be supported by artillery fire. As it may not be possible for guns to afford support from positions behind the wood, some guns may have to be run up to the edge of the wood. The Germans did this at Worth and it was the fire of these guns that enabled the German infantry to debouch from the Elsasshausen Copse and make their attack on Elsasshausen village. The R.E. may be required to make the road for the guns through the wood, and to prepare gun pits for the guns, defiladed or blinded as far as possible from the hostile gun positions.

In defence the R.E. will be equally fully employed, though their work will naturally be on rather different lines.

Woods may be held defensively for a variety of reasons, viz.:—

(*a*). As an advanced post to break up the enemy's attack—as the French held the wood near La Folie at Gravelotte, and as the Austrians held the Swiepwald at Sadowa.

(*b*). As part of the main defensive line.

(*c*). As a pivot on which to hinge an offensive movement.

In the last case, the object of the defenders will be more to deny the wood to the enemy, with a view to protecting the flank of the offensive movement, than to develop much fire from the edge—though a certain amount of fire to the flank will no doubt be aimed at.

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The reason for which it is decided to hold a wood will affect the manner in which the task should be carried out, and so also the work of the R.E. But in most cases the question of the advisability of holding the front edge will come forward, and will have to be decided. As this point was discussed at some length in the August article it is not proposed to enter into the *pros* and *cons* here. But presuming that it has been decided to hold the front edge, in what way can the R.E. be best employed before the action commences? There are two methods of keeping the enemy from gaining or maintaining himself in the edge of the wood. The first is by posting one's men at the edge with the object of fighting there, and holding out then to the end. In this case the defenders are liable to be exposed to heavy artillery fire without the support of their own artillery. Consequently they will need all the protection that the resources of the Engineer can give them. Good overhead cover will have to be provided to guard against shrapnel, and the R.E. will probably be called upon to make it. Again, as high-explosive shell will probably be used against the defence works, the trenches must be so designed as to localize the burst of one of these shell as much as possible. If the trench is constructed exactly at the edge of the wood, traverses will not be easy to make, and the Engineer will be called upon to advise and assist in this matter. Further, if time permits, the desirability of making bombproofs will have to be considered, and, if necessary, a suitable form of bombproof evolved. Again, field or machine guns may be used for close defence and for flanking the front of the wood. They will have to be dug in and given very substantial protection on their outer flank. The Engineers may be required to see to this. In fact, when the front edge is being held in strength, the Engineers will have their hands full.

The second method of holding the front edge of the wood is, to use an Irish expression, not to hold it at all in strength, but keep the bulk of the defenders handy a short distance inside the wood, ready to counter-attack the enemy with the bayonet as soon as he has gained the edge. This was the method adopted with such signal success by the 3rd Zouaves at the Battle of Worth. Generally speaking this method is the best, as the defending troops are demobilized far less than if they were all tied down to defence works at the edge. A small proportion will have to line the edge, more with the object of delaying the attack and causing some confusion than with seriously disputing the advance to the edge. In this case also the R.E. can be of much assistance to the infantry. As the essence of the defence in this case is the counter-attack, the R.E. should be employed in such a manner as to assist the counter-attack. This can be best done by improving the communications through the wood so that the defenders can move rapidly and easily form one point to another. Small breastworks would also be useful in various places, just sufficient to check the advancing enemy, and

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give the defenders an opportunity of making a successful counter-attack. The troops lining the edge will also have to be protected as well as possible, and communications to the rear will have to be made by which they can withdraw when the time comes to do so.

The question of the desirability of holding a line some distance in front of the wood was discussed in the August article, and need not be referred to again here, except to point out that the R.E. will have to assist in the preparation of covered communications between the edge of the wood and the trenches.

A line behind a wood affords many advantages from a defence point of view. It is usually so very strong that the numbers of the defenders may be very greatly reduced and they will depend on fire action rather than shock. The strength of such a position lies in the enormous difficulty troops experience in debouching from a wood under fire, and in the fact that usually the defence is superior to the attack in artillery fire at this point. The difficulty experienced by the Prussians in debouching from the woods of Maslowed and Sadowa in 1866 is a case in point. The Engineers can help the defence best by making these difficulties greater than ever, and entangling certain portions of the edge of the wood, thereby restricting the length from which the enemy can debouch. Arrangements must be made that the unentangled portions of the edge are under very effective rifle fire, which should be cross-fire whenever possible. Land mines also, suitably placed, would be of much service to the defence. In the trenches themselves head cover will have to be provided, though "overhead" cover may not be necessary.

As the number of rifles of the defence will be small, each rifle must be able to develop the fullest amount of fire, and the head cover will have to be designed accordingly. The R.E. will, at any rate, have to advise in this matter, while the bulk of their work will be at the edge of the wood.

As the difficulties of debouching from the wood by day are so great, the enemy may try to emerge by night. This being so, a system of flares, alarms, obstacles, etc., will have to be arranged beforehand. This provides more work for the R.E., whose hands will probably be more than full.

The foregoing remarks are intended to show that the R.E. are in a position to help the infantry enormously in wood fighting, and that there will be no question of their not having enough work to keep them fully employed. As we are certain to have a great deal of wood fighting in the event of service in a civilized country, the importance of specially studying the question is apparent. In some stations, no doubt, the work can be actually practised by the R.E. companies in conjunction with infantry. In others this is not so easy, but much good can be done by the use of outdoor exercises for officers and N.C.O.'s, and by discussing on the ground the small details of the work that would be carried out.

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THE SIPHON AS AN AID TO WATER SUPPLY.

By CAPT. E. W. S. MAHON, R.E.

As military text books contain no mention of siphons as an aid to water supply, the following short description of one, which was successfully installed in Sierra Leone recently, may prove of interest.

The chief advantages claimed for this method of water delivery are that the action is automatic, the labour and expense of pumping is avoided, the discharge can be easily controlled, and, when once in proper working order, a few minutes' attention daily is all that is necessary to maintain the flow from the siphon. All the pipe can be laid above ground, or sufficiently near the surface to make it easily accessible for repairs.

Siphons have I believe frequently been used in connection with reservoirs which are so situated as to provide a gravitation supply, and it would appear to be an advantageous system to follow for this purpose, as all possibility of failure of the dam (should one exist) or of draining the reservoir, owing to leakage in connection with the outlet, is absolutely precluded. Since there is undoubtedly a limit to the size of pipe which can be made perfectly air-tight (the first essential for a siphon), the number of siphons to serve a reservoir might have to be multiplied to ensure delivery of the requisite supply; this would, however, be no disadvantage since it would increase the facilities for controlling the discharge.

Siphons can be used for draining areas and excavations, or for extracting water from underground supplies; for these purposes they can of course only be employed in certain localities where water is met with comparatively near the surface, and where the delivery pipe from the siphon can be graded at a slope, which will enable the end of it to be taken low enough to induce a sufficient discharge within a reasonable distance.

In all cases the delivery end of the siphon should be below the lowest level to which it is desired to drain the reservoir or area (which is limited by a depth of 27 ft. or 28 ft. below the highest point of the siphon). The delivery pipe should be graded downwards from the highest point at a uniform or a gradually increasing slope throughout; there should at any rate be no " concave " bends in the grade unless absolutely unavoidable, as they favour the formation of air pockets; and any upward grading is fatal to the proper working of

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a siphon unless provision is made for extracting air at the top of the bend. The outlet at the end should be controlled by a valve or tap of smaller bore than the pipe, to obviate any possibility of air admission at this point when discharging full bore.

Every joint must of necessity be made perfectly air-tight, but since air is contained in greater or less quantities in the water itself, provision must be made for periodically extracting any air which may accumulate at the highest point in the siphon, without interrupting its flow. This can be best effected on the air-lock principle, by adding an air-collecting chamber at the highest point of the system, controlled by valves at both ends, into which water can be poured to replace any accumulated air. This arrangement also provides an inlet for filling the siphon.

The siphon fitted up at Sierra Leone, is for use in connection with the water supply to Tower Hill Barracks, which usually falls below normal requirements towards the end of the dry season in April and May. With a view to supplementing the supply, trial borings were made in the catchment area containing the streams which provide it, and water was found at a depth of about 12 ft. below the surface in such quantities as to indicate the existence of an extensive underground reservoir. The water-bearing stratum consisting of fine sand, and gravel 6 in. to 1 ft. thick was found to be held between an upper stratum of laterite clay about 10 ft. thick and a lower stratum of syenite; the water in it was borne under pressure sufficient to raise it to within about a couple of feet of the surface as soon as the clay stratum was pierced.

Two boreholes were sunk within 40 ft. of each other and lined with 4-in. C.I. pipes; a 2-in. G.I. pipe was inserted in each and connected up to form the double siphon as shown in *Plate* I. The delivery pipe was carried down the valley a distance of 530 ft. and closed with a 1½-in. tap, discharging into a funnel screwed in the top of the 4-in. C.I. pipe which carries the main supply from the Catchment Area to Tower Hill.

Plate II. shows the grading of the delivery pipe and also of the 4-in. main. The point at which the connection was made was selected both with a view to the head necessary to induce the discharge required, and also because the steep change of grade in the 4-in. pipe enabled a junction to be made there without affecting the flow of the main supply within it.

The point of discharge is 25·3 ft. below the level of the highest point of the system at the junction of the two branches; 13 ft. below the bottom of the siphon pipe in the boreholes; and about 22 ft. below the normal level of water in the boreholes during the driest season of the year. The head at the point of discharge would appear to be the number of feet that point is below the level of water in

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the borehole, added to the head of upward pressure there (which increases as the water level is lowered).

At the end of the dry season with 10 ft. water normally in the boreholes, a discharge of 20 gallons a minute, or 28,800 gallons a day, was obtainable by lowering it 6½ ft. or to 15·7 ft. above the level of the point of discharge.

In the wet season the level of water was a foot higher in the boreholes, and a discharge of 24 gallons a minute, or 34,560 gallons a day, was obtainable with a lowering of 6¼ ft. in the water level to 16¾ ft. above the point of discharge.

The maximum increase required for water-supply purposes at Tower Hill at the end of the dry season is, under present conditions, 10,000 gallons a day, so that the supply obtainable through the siphon is more than ample; still, as there is always the likelihood of increasing consumption in the future, it would be an advantage to replace the boreholes by a well; in addition to the much larger yield which would thereby be obtainable the possibility of stoppage of the siphons through silting up of the boreholes would be avoided. The system of boreholes was resorted to when the work was taken in hand, because there were no pumping or well-sinking appliances available in Sierra Leone, and the extra water was urgently required.

The joints of the 2-in. G.I. pipe were screwed in with hemp and red oxide paint, mixed in the following proportions:—2 lbs. red oxide, ¼ lb. driers, ½ pint boiled oil, ¼ pint turps; they were also well caulked and painted on the outside; by this means all the joints were made absolutely air-tight.

The arrangement for filling the siphon and extracting air is shown on Plan A, the instructions explain the working. The hand pump was added to one branch of the siphon for convenience, but should preferably be separate, and instead of pumping direct into the air lock, the water could be raised (by an automatic pump if desired) to an elevated tank and piped to deliver to the air lock through a tap; this would in any case be the best arrangement where more than one siphon is involved.

I found that the force of the flow of discharge created a vacuum in the air lock, and that the amount of the vacuum increased with the rate of delivery from the siphon; water was displaced for a length of 14 ft. in the 2-in. pipe while the siphon was delivering at the rate of 20 gallons a minute, and for 17 ft. 6 in. when the rate was 24 gallons a minute. The formation of this vacuum did not appear to affect the working of the siphon in any way, as the rate of delivery remained constant whether the air lock was open to the siphon or not.

I also found that an apparent vacuum of about 2 ft. 8 in. of the 2-in. pipe remained in the air lock when the delivery end of the

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siphon was closed, the reason of this is not obvious, and I regret I had not time to investigate it thoroughly; could it be due to the artesian nature of the supply affecting the head of pressure at the foot of the siphon in the borehole?

It is hoped that a consideration of the successful results achieved by this siphon in Sierra Leone may be of assistance when other water supply and drainage schemes are in course of preparation, as not only is a siphon more easily and cheaply installed than any pumping system, but the cost of working and upkeep should be very small in comparison, which of course is greatly in its favour.

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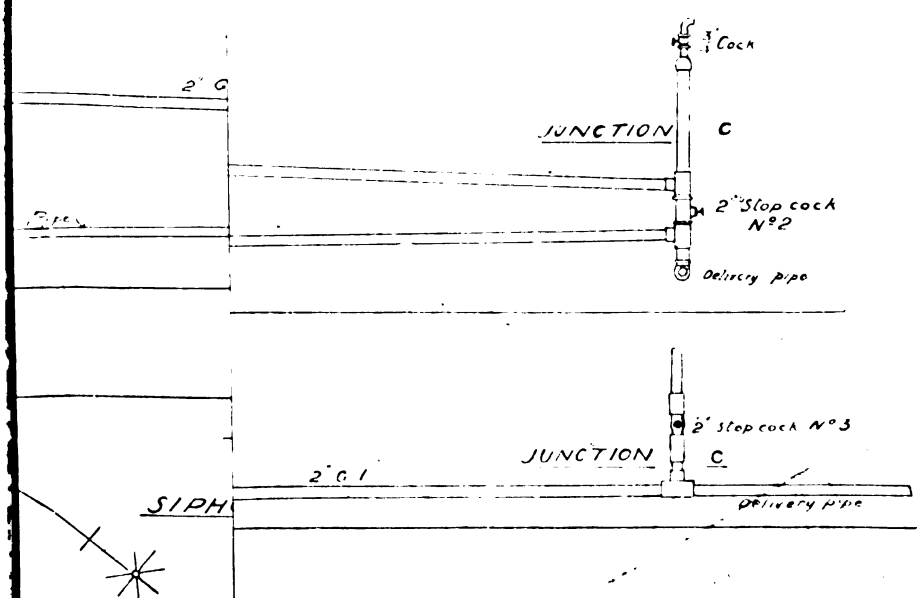

SECTIONAL ELEVATION B-C.

INSTRUCTIONS.

TO FILL AND START THE SIPHONS.

1. Close Stop Cocks 1 and 2.
2. Open ,, ,, 3 ,, 4 and ¾" Cock.
3. ,, ,, ,, 5 ,, pump.
4. Close Tap a at junction with 4" Main as soon as water flows freely.
5. Continue pumping till all air is extracted and water flows freely from the ¾" Cock. Then —
6. Close ¾" Cock and Stop Cocks 4 and 5.
7. Open Stop Cocks 1 and 2.
8. ,, Tap to 4" Main.

TO EXTRACT AIR WITH SIPHONS IN USE.

1. Close Stop Cock 3.
2. Open ,, ,, 4 and ¾" Cock.
3. Pump till air-lock pipe is full, opening Stop Cock 5 for this purpose. Close immediately.
4. Close ¾" Cock and Stop Cock 4.
5. Open Stop Cock 3.
6. After a pause repeat above process until air-lock pipe remains full.

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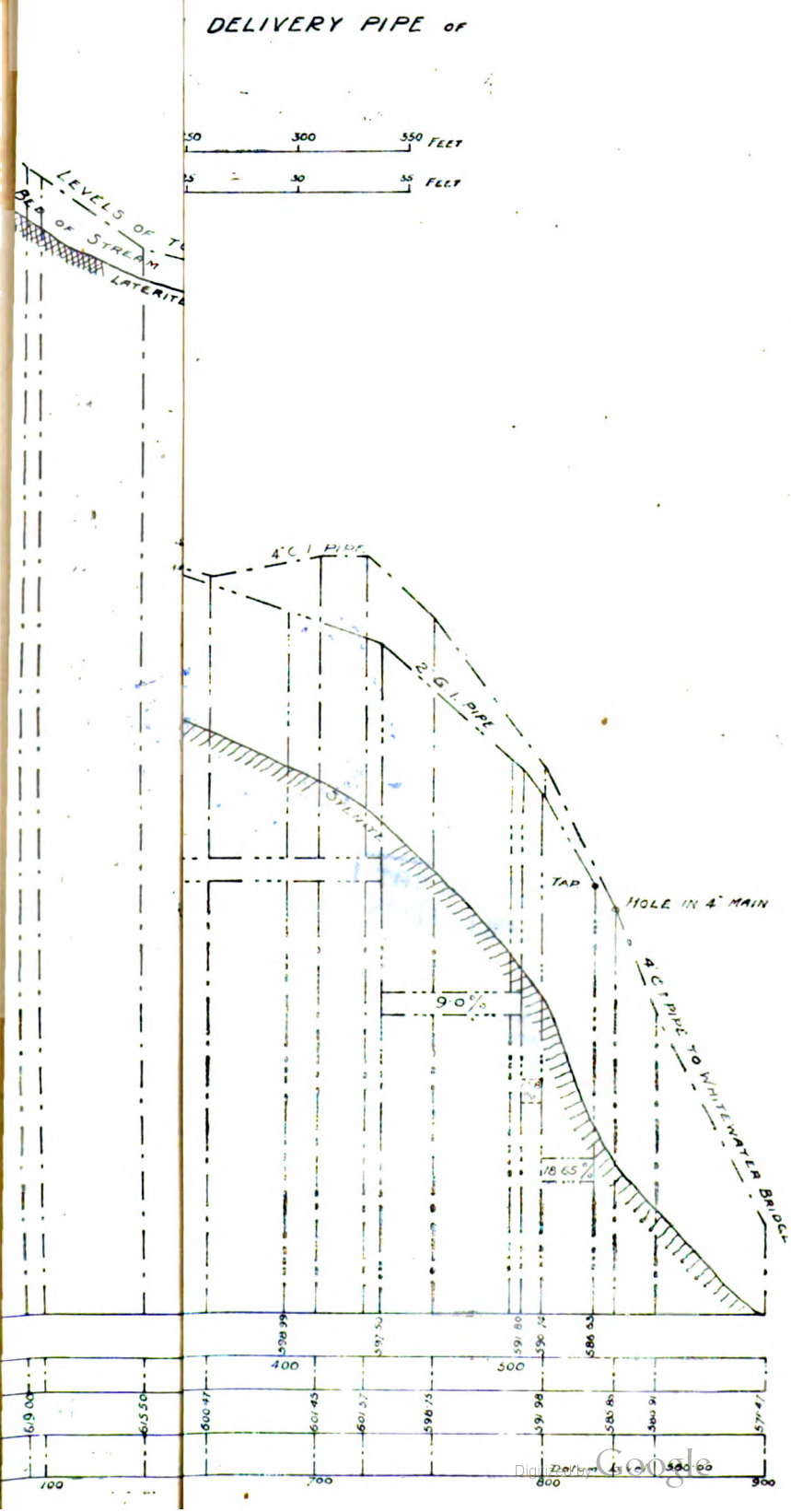
PLY.

PLATE II.



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CONSTRUCTION OF AN OBSERVATORY FOR ARTILLERY RANGES, SALISBURY PLAIN.

By LIEUT. E. WOODHOUSE, R.E., 57th (Field) Co., R.E.

THE observatory shown on the attached plates and photographs was constructed by the 57th (Field) Company in April, 1913, as a part of the annual fieldworks course, and is intended for observation of fire on the Larkhill Artillery Range.

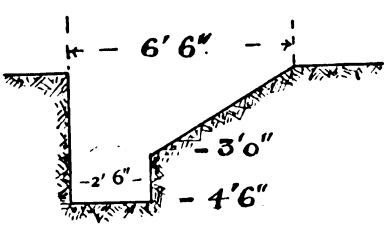
As there is a possibility of its being replaced in the future by a permanent steel structure, it was so designed as to leave the timber fit for subsequent use as far as possible. Mortices were therefore avoided in the joints, which are made with bolts and nails. At the same time, as the site on which it stands is very exposed, it has been solidly constructed throughout.

The constructional details are shown in *Plates* I. and II. The four sides are all alike with the exception of one diagonal in the top panel but one, which is specially constructed to allow access to the lower platform. Each of the four sides was put together and bolted up while lying on the ground at Bulford; each separate piece of timber was then marked to identify it for re-erection, prior to dismantling. The holes for the bolts were bored right through the several thicknesses of timber at the joints at one operation, with a view to ease in re-erection.

METHOD OF ERECTION ADOPTED.

The two legs "C" and "D" with the various members connecting them and the raking struts joining them to the ends of their own 26-ft. sills were put together on the ground and permanently bolted and nailed together (*Photos* 1 and 2). The four scarf joints in the legs were temporarily strengthened for erection, by 8-ft. lengths of 9-in. × 3-in. plank bolted on outside with $\frac{3}{4}$-in. bolts (*Photo* 2).

While the construction of this first frame was in progress a trench 27 ft. long × 4 ft. 6 in. deep × 2 ft. 6 in. wide was dug close to the sill of the frame, and the side of the trench towards the frame was sloped off as under.



Cross Section of Trench.

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Four or five short lengths of timber were laid transversely in the bottom of the trench, and these were levelled through. The frame was built on lengths of 9-in. × 9-in. timber (portions of the remaining two legs) which had been packed up to the same plane in order to obviate any possibility of its being made "on the twist." The bolts for connecting the two legs of this frame with the horizontals leading to legs "A" and "B" respectively, had to be put in with their heads inside the legs as their tails would have fouled the ends of the inside diagonal members. They were therefore driven into legs "C" and "D" before this frame was put together. Some of these bolts were made use of to attach the temporary strengthening pieces for the four scarfed leg joints (*Photo* 2).

When the trench and frame were completed the latter was carried forward till the sill was over the trench. The portion of the frame to be buried was then tarred. It may be mentioned here that all joints in the structure were put together with a coat of tar between the surfaces.

While the above work was in progress a party had been employed in stretching and examining all ropes to be used in raising the frame and in preparing tackle and picket anchorages.

Method of raising Frame and Description of Tackle.—The frame was raised into an inclined position by two derricks, one on each side of it, and then was hauled into an upright position by a winch on a head guy. When tested for plumb, it was found to be leaning slightly to one side, the top being 2 in. away from the vertical. This was corrected by keeping a strain on one side guy, while the lower end of the sill was levered up. A bight of double 3-in. rope had been left in each end of the trench before the frame was raised, and a 16-ft. section of one of the remaining legs was applied to this rope as a lever.

The bottom sections of legs "A" and "B," each 20 ft. long, 9 in. × 9 in., were used as derricks. To obtain as much lift as possible from them they were erected with their lower ends 28 ft. from the sill of the frame. The derrick falls lifted the frame at a point immediately above the top scarfed joints of the legs. Before lifting, the strength of these joints was tested by levering them up with handspikes; they were found to deflect $\frac{5}{8}$ in. before the head of the frame lifted from the supports on which it was resting. The derricks might have lifted the frame at a point nearer the sill, but it was feared that the scarfed joints would suffer if this was done.

With a view to further increasing the lift obtainable from the derricks, the standing ends of their falls were not made fast to the top blocks in the usual way but to the slings from which these hung, thus enabling the tackle to be hauled up till the top and bottom blocks were actually in contact with one another. In addition to this, the movable blocks of the derrick tackles were

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not made fast to the legs of frame, but were lashed as close as possible to a beam made of three 12-ft. lengths of 6 in. × 2 in. on edge (afterwards used in decking of platforms) bolted and nailed together. This beam was passed under the legs, and was prevented from slipping towards the derricks by the projecting tails of the bolts in the scarfed joints of the legs.

This arrangement also ensured that the frame would leave the derrick tackles behind without difficulty as soon as the head guy took the weight.

The derricks were heeled inwards towards the frame and were not provided with fore guys. There was no risk of their falling outwards when relieved of their load as the above-mentioned beam on which the frame had been resting was by this time close to the heads of the derricks, and held them together.

List of Derrick Tackle, etc. (each derrick had to lift approximately 12 cwt.).

Falls	2-in. white rope.
Back guys	3-in. tarred single.
Side	3-in. tarred single.
	(In one case 2-in. white double).

Two double 2½-in. blocks used for falls.

Picket holdfasts used for guys.

Photo 1 shows frame when raised as far as possible by the derricks. While being thus raised the sill of the frame was allowed to slide down boards against the back of the trench. The frame was then raised to an upright position by a head guy. A 1-ton winch borrowed from a neighbouring pumping station and anchored to two picket holdfasts was used to haul in this guy with a tackle of 1½-in. wire rope, of which there was 300 ft. on the drum of the winch. As the slope of the ground rendered it possible to place the winch some 4 ft. or 5 ft. higher than the top of the foundation trench, a better angle was obtained for the back guy.

Two single 3-in. blocks were used on the tackle which was attached to the head of the frame by a long sling of four parts of 3-in. tarred rope. The stress in the back guy, obtained graphically, was 33 cwt. when the weight was taken off the derricks. This was borne by three parts of 1½-in. wire rope in the tackle and four parts of 3-in. tarred rope in the sling. The fixed block of the guy tackle was fastened to a 3 : 2 : 1 holdfast of 5-ft. pickets. The actual work of raising the frame with the winch was done by two men.

At the moment when the frame left the derrick the thrust in the legs, obtained graphically, was 46 cwt. As the scarfed joints had to be made short through lack of material, they were temporarily strengthened as previously described. In order to lessen the

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deflection of the frame through its own weight and the above thrust, a light strain was kept on the top scarfed joints by a single 3-in. rope led to a small winch. This rope and also the head guy are shown n *Photo* 2.

ERECTION OF REMAINING THREE FACES OF STRUCTURE.

As soon as the first frame had been raised to a vertical position, the excavation of the remaining foundation trenches was proceeded with. To avoid widening the ends of the trenches for the purpose of driving the 17-in. bolts connecting the lower ends of the short raking struts with the ends of the sills, the latter were made in two pieces, with joints about the centre of their length. The raking struts were bolted up to the two half sills on the ground and then lowered into the trenches, the only bolts having to be driven below ground being those for the sill joints which were short (8 in.) and those connecting the sills to the legs which were easily handled in the trenches already dug.

The lower sections of legs " A " and " B," 20 ft. long, were built up into a frame complete with raking struts, sills and lowest panel of cross-bracing. When its foundation trench was ready this frame was easily upended in it by means of head ropes. A little manipulation with levers and slings served to bring it into a correct position with relation to the frame already in place, and then the lowest panel of cross-bracing between legs " D " and " A," and " C " and " B " was fitted into place. When this had been accomplished and the legs checked over with a plumb-bob the foundations were filled in, the chalk being well rammed as it was returned.

The following method was employed to raise the remaining two 16-ft. sections of legs " A " and " B." :—Two frames were made, each consisting of a pair of 16-ft. lengths of 6-in. × 3-in. timber bolted together, with 9-in. distance pieces between. The pulley of a 2½-in. single block was housed in the distance piece at one end of each frame, and was free to revolve on a ¾-in. bolt passing through both the distance piece and the cheeks of the frame. The frames were attached to the heads of legs " C " and " D " by a single ¾-in. bolt, about which they were free to revolve through a small arc, and were used as crane jibs to lift the sections of legs " A " and " B " into place. The ends remote from the pulley were each anchored to the lower part of the main frame by a 2½-in. rope. A single 2-in. white rope was rove through the pulley at the end of the jib, a snatch block at the head of the leg and a snatch block lower down the frame, whence it was led away to the warping drum of one of the borrowed winches. The pivot bolt of the jib was 9 ft. from the pulley and, as the legs of the structure are 8 ft. apart centre to centre, it was possible, by raising the jib above the

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horizontal, to swing the middle and top sections of legs "A" and "B" into place without difficulty.

Failing some contrivance of this sort it would have been difficult to erect these legs, as each section weighed about 300 lbs., and had to be manœuvred into its exact position while the scarf joints were bolted up. By the use of the winch two men were able to do this to a nicety. These cranes were also of assistance in raising other parts of the structure into place. They are clearly shown in *Photos* 1 and 2 and in *Photo* 3 one of them is shown lifting the top section of leg "B."

After the bottom sections of legs "A" and "B" had been brought into their proper positions with reference to legs "C" and "D," no difficulty was experienced in erecting the remainder of the structure, as all the members were found to fit together well with bolt holes in register. Some little discrimination was required in deciding which of the bolts connecting diagonals with horizontals should be driven from the inside, and which from the outside of the structure, as these had to be put in before all the timbers they connected were in place.

Two movable stagings were constructed for the use of the erecting party. These consisted of 9-in. × 2-in. planks on edge, 20 ft. long, clamped to the legs by "U" bolts of 1½-in. × ¾-in. half round iron, screwed ¾ in. at the ends. One of these planks was clamped to each pair of legs and served both to hold them in place till the cross-bracing was fixed and to support planks for the erecting party to stand on. The 9-in. × 2-in. planks were afterwards used as decking for the top platform. These stagings are clearly shown in *Photo* 3.

With the exception of the four strengthening pieces for leg scarfs in the frame first erected and the crane jibs described above, all timber used for temporary purposes during erection was afterwards used up in the structure. An extra 20-ft. ladder was taken out but was very little used and could have been dispensed with. The crane jibs could have been dismantled and used for diagonals to top panel but were of some service after the top panel was completed.

Photo 4 shows the completed structure.

Detail of Man-Hours Worked.

The number of man-hours worked on the structure at Bulford was 618. Of these, 106 were worked by smiths making and shortening bolts, and making other iron work. 156 were worked by fitters, running down threads on bolts purchased or drawn from store, none of which were screwed far enough down, and screwing bolts made by smiths. The remainder, 356 man-hours, were worked by carpenters on the structure itself and by men assisting them.

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Two sergeants and 30 men were employed on the erection of the structure, which occupied five days. The number of man-hours worked, exclusive of the two sergeants superintending, was 988, of which 400 were worked by carpenters.

CONCLUSION.

The earlier part of the erection was partly delayed by the excavation, which totalled 1,512 f.c. and was concentrated in a small space, so that the men employed were inclined to hamper one another. Shallower foundations would probably have sufficed, but it must be remembered that the structure is in a very exposed situation. On the last two days, work was much hampered by a very high wind accompanied by much rain.

If the structure had been built on the ground as two frames, instead of the second frame being put together piece by piece in the air the work would have been expedited, but it was feared that there would have been considerable difficulty in getting the second frame into register with the first after raising, in view of the fact that they each weighed about 46 cwt. Probably the best way of doing this would have been to raise the second frame with a derrick, but as a matter of fact there was no spar available in store for a derrick of the necessary height and strength.

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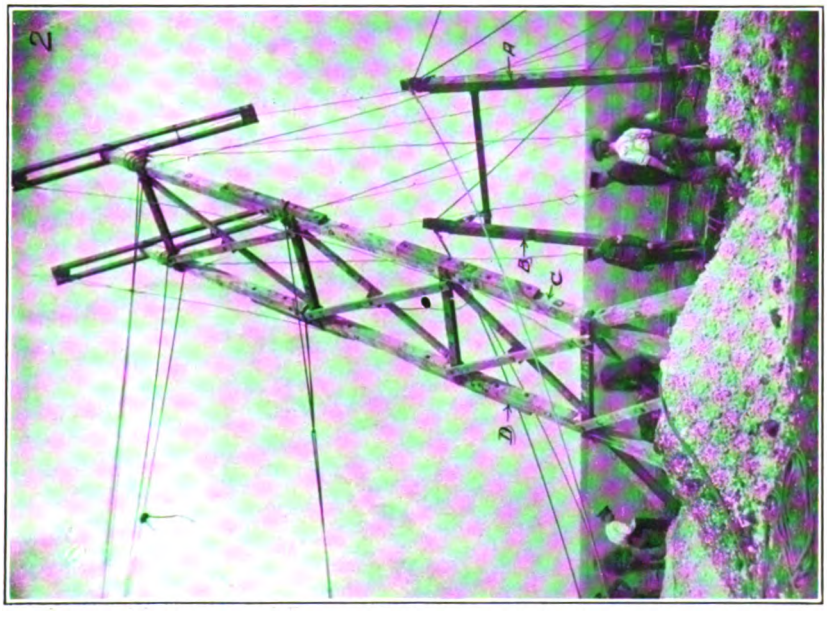
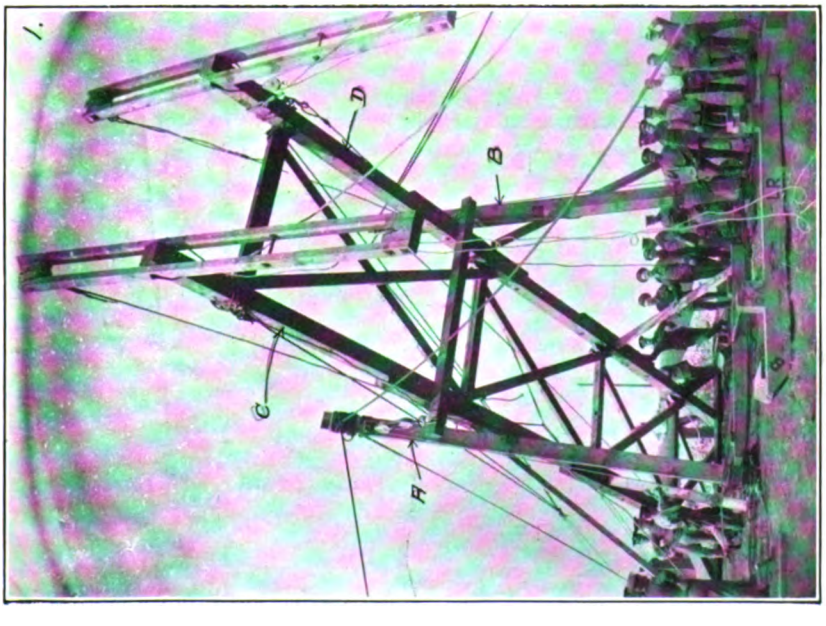
CONSTRUCTION OF AN OBSERVATORY FOR ARTILLERY RANGES.



Frame being raised by guys.



Position of frame raised by derricks.

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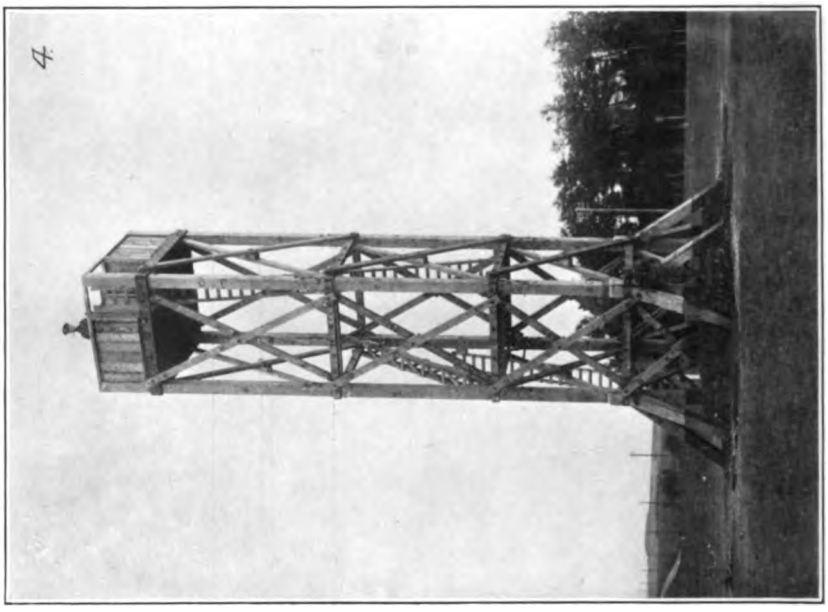
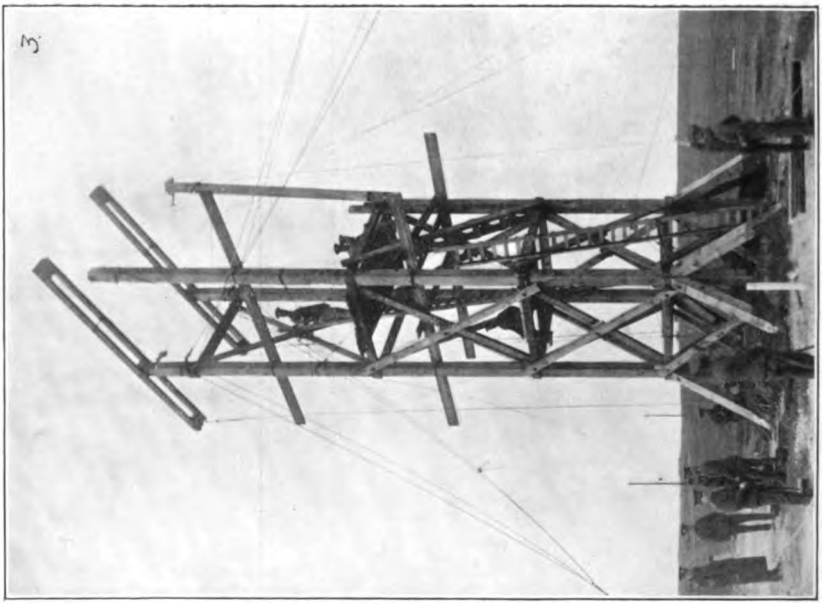


Observatory completed.



Jib cranes in use.

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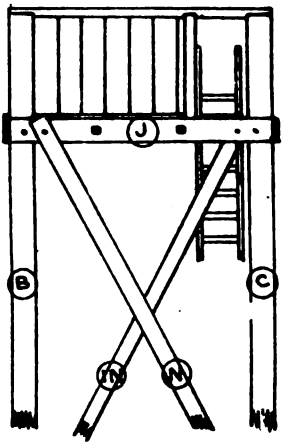
RVATORY FOR ARTILLERY RANGES.



Side Elevation of Top Panel.

" Bolt

adders have 4"x2" cheeks 4" apart in clear. Rungs at 9" centres, 3"x1½" or 2"x2"

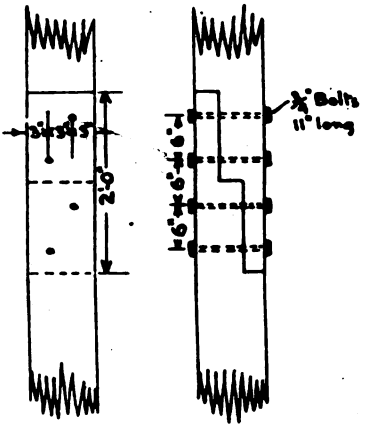
/11" Bolts in Leg Scarfs

Horizontals 6"x2" with 6"x2" behind.

This diagonal omitted on this face only. Other diagonal is 2/6"x2", one inside and one outside with 3"x1½" lacing between.

Bolt

" Bolt



All Bolts are ¾" dia. with 2/3"x3"x⅛" Washers.

Details of Leg Scarfs
¾" = 1ft

17" Bolt

Raking Struts 9"x9"x1¼"
(9"x9"x13'-6" to Short Sills)

Bolt
evel

Letters in circles refer to marking for Re-erection.

End of Short Sill

ort Sills
25'-0"

(S) Out

" Bolts

¾/17" Bolts

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TILDEN FOUNDATIONS

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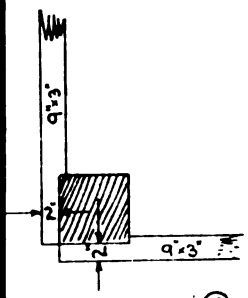
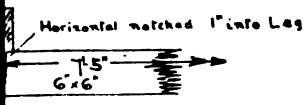
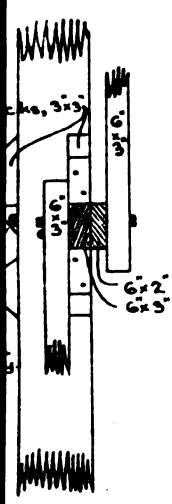


Joint of Horizontal (J) with Leg



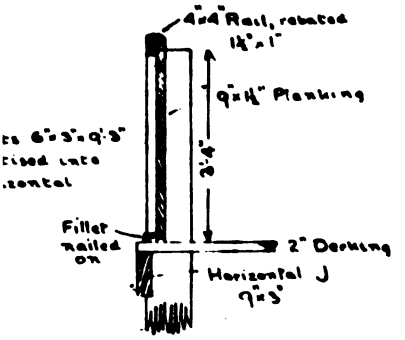
Horizontal (F) with Leg

3/4" = 1 ft.



etails of Joints of Legs
orizontals, and Diagonals

3/4" = 1 foot.



Arrangement of Railing to Top Platform.

ARTILLERY RANGES

Prospect Observatory.

Scales 1/4", 1/2", 3/4" = 1 foot.

Ells
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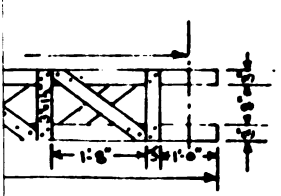

Diagonal (M).

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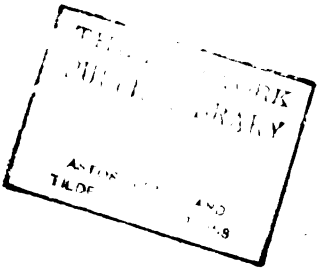

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EARLY INDIAN CAMPAIGNS AND THE DECORATIONS AWARDED FOR THEM.

SUTLEJ CAMPAIGN. 1854-6.

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EARLY INDIAN CAMPAIGNS AND THE DECORATIONS AWARDED FOR THEM.

(*Continued*).

By MAJOR H. BIDDULPH, R.E.

THE SUTLEJ CAMPAIGN, 1845–6.

The anarchy that ensued soon after the death of Runjeet Singh in 1839, culminated in the Sikh Army crossing the Sutlej and invading British territory in December, 1845. The Governor-General (Sir H. Hardinge), who was touring on the frontier at the time, immediately issued orders for the concentration of the British troops under Sir H. Gough, the C.-in-C., and marched with them himself.

Ten days after leaving their cantonments, and in which they covered 150 miles, the advanced portion of the British Army came into contact at Moodkee, on 18th December, with a detached corps of the Sikhs, thrown out in front of their main army and entrenched camp at Ferozeshah.

The battle began with artillery fire, while the British infantry advanced in echelon of brigades and deployed. Meanwhile the small force of British cavalry was directed to turn *both* flanks of the vastly superior force of the Sikhs. Both charges were executed with the greatest gallantry and success, and the infantry, advancing in echelon of lines, drove back the enemy with the bayonet, until night and weariness put an end to the battle.

Great confusion prevailed during the battle, the infantry had come into action, after a long march through deep sand, with stragglers stretching out for miles in rear; a dust storm was blowing, and many casualties were caused (as in other battles of this war) by the Native regiments, which lagged behind, firing into the European regiments in front.

The Sikhs lost some 17 guns and fell back on their main army at Ferozeshah.

The next day, H.M. 29th Foot, the 1st Bengal Europeans, and other troops arrived, and the Governor-General tendered his military services to Sir H. Gough, as second-in-command.

On the 21st December the army resumed its march, but, by the personal order of the Governor-General, the Commander-in-Chief was forbidden to commence the attack on the Ferozeshah entrenchments until (as arranged) Sir John Littler, who had slipped out of

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Ferozepore, leaving a small garrison to oppose Sirdar Tej Singh, had effected a junction.

This took place early in the afternoon, and the assault on one of the longer faces of the camp then took place. Sir John Littler's division was on the extreme left. Sir H. Hardinge commanded the left wing of Gough's force and Gough commanded the right wing on the right flank.

The Sikhs numbered 47,000 men with 88 guns, according to their own estimate, the British numbered 17,000 men with 69 guns.

Littler's division assaulted the trenches prematurely and unsupported, and was driven back with immense loss; meanwhile the 2nd and 3rd Divisions attacked and penetrated the entrenchments, but could not clear the camp; the 1st Division (in reserve) also succeeded in penetrating the entrenchments. Night had now ensued, all the regiments and brigades were hopelessly mixed up and scattered, and the Sikhs kept up fire during a great part of the night.

In the morning Sir H. Hardinge and Sir H. Gough re-formed such troops as were at hand, and leading the line in person, 20 paces ahead, to prevent premature firing, swept the camp from end to end, driving the Sikhs from the field and capturing 74 guns.

Scarcely had this been effected, when Sirdar Tej Singh with 35,000 men and 100 guns arrived from Ferozepore.

The situation of the British was critical in the extreme; nearly all the artillery ammunition had been fired away, and the troops were worn out. The men were, however, immediately formed up and preparations for attack made, when Tej Singh, bluffed by the British, and doubly cautious after learning how the main army of the Sikhs had been turned out of their entrenchments, withdrew.

The British losses totalled 2,877; and, as before, the European regiments had to do most of the fighting. Sir H. Hardinge, who had served throughout the Peninsular War, considered the Bengal Native regiments much on a par with Portuguese troops, and that like them they had their fighting days. Unfortunately the 21st December was one of their non-fighting days.

The Sikhs now took up a position at Sobraon, with the Sutlej and their bridge of boats immediately in their rear, and spent their time entrenching themselves again. The chance of giving them a knock-out blow in this position was recognized by Sir H. Hardinge, and they were left there unmolested, pending the arrival of reinforcements and a siege train.

Meanwhile a Sikh Sirdar crossed the Sutlej higher up, threatening Ludhiana and the British communications. Sir H. Smith was detached to deal with him, which he did most effectively at the Battle of Aliwal on 28th January, 1846. Each arm was given full scope, the infantry advanced in line, covered by artillery fire, with cavalry on either flank. The enemy's left was turned and their

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line crumpled up and taken in reverse. The Sikh right, composed of Avitabile's crack battalions, clung to their ground to cover the passage of the Sutlej in rear, until H.M. 16th Lancers broke their square and the whole army was driven pell-mell across the river with the loss of every gun (67 in all), and at least 3,000 men.

The only point east of the Sutlej now held by the Sikhs was their bridgehead at Sobraon, and as soon as the siege train and reserve ammunition arrived, Sir H. Gough and Sir H. Hardinge planned the assault.

The Sikh entrenchments were held by 35,000 troops (exclusive of irregular cavalry), with 70 guns, while 50 pieces of heavy artillery were posted on the right bank. The British force *engaged* numbered 16,000 men. The engagement began by a heavy cannonading, but the infantry attack had to be launched prematurely owing to the expenditure of gun ammunition—one of the chief defects revealed by the campaign being the shortage of gun ammunition carried in the field by the artillery.

The 3rd Division, on the left, first penetrated the entrenchments, followed soon after by the 2nd and 1st Divisions on the centre and right. For an hour the battle raged inside the position before the Sikhs were broken, but by midday the enemy had been driven across the river; during their passage the bridge broke, and the river, which had risen several inches during the night, swept the Sikhs away by hundreds, while the horse artillery played upon them unceasingly from the river's edge. No less than 10,000 Sikhs perished that day, the position and sandbanks in the river were thickly piled with corpses, and 67 of their guns remained in our possession.

The British crossed the Sutlej the same day, and on the 20th February arrived at Lahore. Under the terms of the treaty of peace the remainder of their heavy guns, used in action, had to be surrendered.

The war occupied almost exactly two calendar months, during which four big battles were fought, over 200 pieces of artillery captured on the field, and nearly 7,000 casualties sustained in action, of which the few British regiments suffered no less than 3,600, out of a total strength of a little more than 9,000 of all ranks.

Sir H. Hardinge authorized, in the first instance, the medals for this war; and, following the rule followed in the Peninsula, directed that medals should be given for the battles only, the name of the first battle in which the recipient was engaged being on the reverse of the medal, while those of subsequent battles were on clasps attached to it.

Sutlej Campaign, 1845–6.

Obverse.—Crowned head of Queen Victoria. Legend: "Victoria Regina."

Reverse.—Victory standing beside a trophy, holding a wreath in her outstretched hand. Inscription: "Army of the Sutlej."

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Exergue.—(*a*) " Moodkee 1845.
(*b*) " Ferozeshuhur 1845."
(*c*) " Aliwal 1846."
(*d*) " Sobraon 1846."
Clasps.—" Ferozeshuhur."
" Aliwal."
" Sobraon."
Mounting.—Silver scroll bar and swivel. This was the first medal issued with a swivel mounting.
Ribbon.—Dark blue with crimson edges, 1¼ in. wide.

N.B.—The correct name of the village that gave its name to the battle of Ferozeshuhur, is " Ferushahr." This battle honour is spelt officially as " Ferozeshah."

SUTLEJ CAMPAIGN, 1845–6 (Sir H. Gough, C.-in-C.).

Troops present at Moodkee, 18th December, 1845.

Cavalry :—Brigadier M. White, 3rd L. Dragoons.
2nd Brigade :—Brigadier J. B. Gough, 3rd L. Dragoons (wounded at Sobraon).
H.M. 3rd Light Dragoons.
The Bodyguard.
5th Bengal Light Cavalry.
3rd Brigade :—Brigadier W. Mactier, 4th L.C. (wounded).
4th Bengal Light Cavalry.
9th Irregular Cavalry.
Artillery :—Brigadier G. Brooke.
Horse Artillery :—1st Brigade, 1st, 2nd, and 3rd Troops.
3rd Brigade, 1st, 4th and 1 division of 2nd Troop.
Foot Artillery :—3-4th Battn. and 2-6th Battn.
Engineers :—Major R. Napier.*
Infantry :—
1st Division :—Major-General Sir H. G. Smith.
1st Brigade :—Brigadier S. Bolton, 31st Foot (killed).
H.M. 31st Foot.
24th and 47th Bengal N.I.
2nd Brigade :—Brigadier H. M. Wheeler,† 48th B.N.I. (wounded).
H.M. 50th Foot.
42nd and 48th Bengal N.I.
2nd Division :—Major-General W. R. Gilbert, 38th N.I.
2nd, 16th, and 45th Bengal N.I.
(Remainder of Division not yet arrived).

* Later F.M. Lord Napier of Magdala.
† Killed at Cawnpore, 1857.

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3rd Division :—Major-General Sir J. M'Caskill, 9th Foot (killed).
Brigadier W. Wallace, 26th B.N.I.
H.M. 9th and 80th Foot.
26th and 73rd Bengal N.I.
(Remainder of Division not yet arrived).

Casualties :—12 British officers and 203 other ranks killed.
44 ,, ,, 613 ,, ,, wounded.

17 or 19 guns were taken, exact number is uncertain.

Sir R. Sale, of Jellalabad fame, was among the killed.

On the 19th December H.M. 26th Foot, the 1st Bengal European Regt., 11th and 41st Bengal N.I., the 2-4th Battn. and 4-4th Battn. Bengal Artillery arrived.

The 11th and 41st B.N.I. were left at Moodkee to guard the wounded, and the army marched on the 21st to effect a junction with Littler's division from Ferozepore.

Sir J. H. Littler left in garrison at Ferozepore the 27th and 63rd B.N.I., the 2-2nd Battn. Bengal Artillery, 3 guns of 2-7th Battn. Bengal Artillery and a detachment of Bengal Sappers ; and marched with the 8th Bengal Light Cavalry and the 3rd Irregular Cavalry, 5-1st Brigade and 3-3rd Brigade Bengal Horse Artillery, 4-6th Battn., 3 guns 2-7th Battn. and detail of 2-2nd Battn. Bengal Artillery, detachment of Bengal Sappers, the 7th Infantry Brigade (H.M. 62nd Foot, 12th and 14th B.N.I.) and 8th Infantry Brigade (33rd, 44th and 54th Bengal N.I.).

Troops present at Ferozeshah, 21st, 22nd December, 1845.

Cavalry :—Brigadier D. Harriott, 8th Ben. L.C. (wounded).
1st Brigade :—Brigadier M. White, 3rd L. Dragoons (wounded).
H.M. 3rd Light Dragoons.
4th Bengal Light Cavalry.
9th Irregular Cavalry.
2nd Brigade :—Brigadier J. B. Gough, 3rd L. Dragoons.
The Bodyguard.
5th Bengal Light Cavalry.
3rd Brigade :—Brigadier D. Harriott (commanding the Division).
8th Bengal Light Cavalry.
3rd Irregular Cavalry.

Bengal Horse Artillery :—Brigadier G. Brooke.

Bengal Foot Artillery :—Brigadier G. G. Dennis.
1st Brigade H.A. :—1st, 2nd, 3rd and 5th Troops.
3rd Brigade H.A. :—1st, 3rd, 4th, and 1 division of 2nd Troops.
4th Battn. :—2nd, 3rd and 4th Cos.
6th Battn. :—2nd and 4th Cos.
7th Battn. :—3 guns of 2nd Co.
Also detail of 2-2nd Battn.

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Bengal Engineers :—Major R. Napier.
No. 6 Co., Sappers and Miners.
1st Infantry Division :—Major-General Sir H. G. Smith.
1st Brigade :—Brigadier G. Hicks, 47th B.N.I.
H.M. 31st Foot.
24th and 47th B.N.I.
2nd Brigade :—Brigadier T. Ryan, 50th Foot.
H.M. 50th Foot.
42nd and 48th B.N.I.
2nd Division :—Major-General W. R. Gilbert.
3rd Brigade :—Brigadier C. C. Taylor, 29th Foot (wounded).
H.M. 29th and 80th Foot.
45th B.N.I.
4th Brigade :—Brigadier J. McLaren, 16th B.N.I.
1st Bengal European Regiment.
2nd and 16th B.N.I.
3rd Division :—Brigadier N. Wallace, 26th B.N.I. (killed).
5th Brigade :—H.M. 9th Foot.
26th and 73rd B.N.I.
6th Brigade :—Absent.
4th Division :—Major-General Sir J. H. Littler, 36th B.N.I.
7th Brigade :—Brigadier T. Reid, 62nd Foot (wounded).
H.M. 62nd Foot.
12th and 14th B.N.I.
8th Brigade :—Brigadier T. Ashburnham, 62nd Foot.
33rd, 44th, and 54th B.N.I.
Casualties :—39 British officers and 681 other ranks killed.
82 ,, ,, 1,686 ,, ,, wounded.
379 ,, ,, missing.
74 guns were captured.

It is to be noted that the troops that guarded the camp at Moodkee, and those that garrisoned Ferozepore, received the decoration for Ferozeshah.

Troops present at Aliwal, 28th January, 1846 (Sir H. G. Smith in command).

Cavalry Division :—Brigadier C. R. Cureton, 16th Lancers.
1st Brigade :—Brigadier G. J. M. McDowell, 16th Lancers.
H.M. 16th Lancers.
3rd Bengal Light Cavalry.
4th Irregular Cavalry.
2nd Brigade :—Brigadier R. A. Stedman, 1st Bengal L. Cavalry.
The Bodyguard.
1st and 5th Bengal L. Cavalry.
Bengal Artillery :—Major G. S. Lawrenson.
Horse Artillery :—1-1st Brigade, 1st and 3rd Troops, 2nd Brigade, 2-3rd Brigade.

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Foot Artillery :—2-7th Battn.
Bengal Engineers :
Detachment, Sappers and Miners.
Infantry :—
1st Brigade :—Brigadier G. Hicks, 47th B.N.I.
H.M. 31st Foot.
47th B.N.I.
2nd Brigade :—Brigadier H. M. Wheeler, 48th B.N.I.
(Brigadier N. Penny, Supernumerary).
H.M. 50th Foot.
48th B.N.I.
Sirmoor Battn.
A Brigade :—Brigadier R. W. Wilson, 30th B.N.I.
H.M. 53rd Foot.
30th B.N.I.
(Wing 24th B.N.I., probably in garrison at Ludhiana).
A Brigade :—Brigadier C. Godby, 36th B.N.I.
36th B.N.I.
Nusseeree Battn.
Bengal Sappers and Miners.
Shekawati Brigade :—Major H. Foster.
Cavalry, Artillery, and Infantry, 1,200 strong.
Casualties :— 4 British officers and 147 other ranks killed.
25 ,, ,, 388 ,, ,, wounded.
25 ,, ,, missing.
67 guns captured or destroyed.

N.B.—A good many details and drafts of other corps were present by accident, and the decoration was given to the garrisons of Ludhiana and Buddhowal Forts.

These included detachments from 2-4th, 4-4th, and 4-6th Battns. Bengal Artillery, Wing 24th B.N.I., etc.

Troops present at the Battle of Sobraon, 10th February, 1846 (Sir H. Gough, C.-in-C.).

Cavalry Division :—Major-General Sir J. Thackwell.
1st Brigade :—Brigadier J. Scott, 9th Lancers.
H.M. 3rd Light Dragoons.
8th and 9th Irregular Cavalry.
2nd Brigade :—Brigadier A. Campbell, 9th Lancers.
H.M. 9th Lancers.
2nd Irregular Cavalry.
3rd Brigade (on the right of the army, near Hurreekee Ford) :—
Brigadier C. R. Cureton, 15th Lancers.
H.M. 16th Lancers.
The Bodyguard.
3rd, 4th and 5th Bengal Light Cavalry.
Bengal Artillery :—Brigadier G. E. Gowan.

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1st Division Horse Artillery :—Brigadier G. Brooke.
2nd Division Horse Artillery :—Brigadier E. Biddulph.
1st Brigade Horse Artillery, 2nd, 3rd and 5th Troops.
2nd ,, ,, ,, 1st, 2nd and 3rd Troops.
3rd ,, ,, ,, 1st, 2nd, 3rd and 4th Troops.
Foot Artillery :—Brigadier G. G. Dennis.
2-2nd Battn. ; 3rd and 4th Cos., 3rd Battn. ; 1st, 2nd, 3rd and 4th Cos., 4th Battn. ; 1st, 2nd, 3rd and 4th Cos., 6th Battn.
Bengal Engineers :—[Brigadier A. Irvine]*.
Brigadier E. J. Smith.
Headquarters and 6 Cos. Sappers and Miners.
1st Infantry Division :—Major-General Sir H. G. Smith.
1st Brigade :—Brigadier N. Penny, Nusseeree Battn. (wounded).
H.M. 31st Foot.
47th Bengal N.I.
2nd Brigade :—Brigadier G. Hicks, 47th Bengal N.I.
H.M. 50th Foot.
42nd Bengal N.I.
Nusseeree Battn.
2nd Infantry Division :—Major-General W. R. Gilbert (wounded).
3rd Brigade :—Brigadier C. C. Taylor, 29th Foot (killed).
H.M. 29th Foot.
41st and 68th Bengal N.I.
4th Brigade :—Brigadier J. McLaren, 16th Bengal N.I. (killed).
1st Bengal European Regt.
16th Bengal N.I.
Sirmoor Battn.
3rd Infantry Division :—Major-General Sir R. Dick (killed).†
5th Brigade :—Brigadier Hon. T. Ashburnham, 62nd Foot.
H.M. 9th and 62nd Foot.
26th Bengal N.I.
6th Brigade :—Brigadier C. D. Wilkinson, 63rd Bengal N.I.
H.M. 80th Foot.
33rd and 63rd Bengal N.I.
7th Brigade :—Brigadier L. R. Stacey, 43rd Bengal N.I.
H.M. 10th and 53rd Foot.
43rd and 59th Bengal N.I.
Reserve 45th Bengal N.I.
At Rhodawalla, 73rd Bengal N.I.
Also present, wing 24th Bengal N.I., detachment 38th Bengal N.I. and 1 co. 12th Bengal N.I.

* Brigadier Irvine waived his right to supersede Smith, as he arrived in camp only just before 10th February.

† Sir R. Dick served with the 42nd Regt. in the Peninsula and at Waterloo.

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Casualties :— 13 British officers and 308 other ranks killed.
102 ,, ,, 1,962 ,, ,, wounded.
67 guns were captured.

The troops at Rhodawalla, and those in reserve, and guarding the Commander-in-Chief's camp received the decoration for Sobraon.

The severity of the casualties in this short campaign of two months, the brunt of which was borne by the European troops, may be gauged from the following :—

3 Major-Generals and 4 Brigadiers were killed.
1 Major-General and 7 Brigadiers were wounded.

The European regiments lost 61 officers and 912 men killed, 128 officers and 2,520 men wounded, equivalent to 50 per cent. of the officers and 40 per cent. of the men.

Strength (approx.) 18. 12. 45.		Corps.	Killed.		Wounded.	
Officers.	Men.		Officers.	Men.	Officers.	Men.
27	518	3rd Light Dragoons ..	6	124	15	142
30	874	9th Foot	4	81	8	267
35	765	29th Foot	4	87	16	331
36	844	31st Foot	9	132	16	352
33	675	50th Foot	8	105	28	445
24	768	62nd Foot	8	91	11	204
26	795	80th Foot	5	63	8	168
26	640	Bengal European Regt. ..	9	80	11	312

Certain of the above regiments received small reinforcing drafts in January, 1846, which are not included in the strengths given ; also many individuals were wounded more than once, and increase the numbers of casualties recorded.

The combination of the Ferozeshah medal with clasps for Aliwal and Sobraon was not earned by a single individual of the Queen's troops, and by only a very few in the Company's service. One or two well-known collections contain faked medals of British infantry with this combination. For practical purposes the combination may be said to be non-existent.

Medals were issued to the 11th Irregular Cavalry, although this corps was not really in existence during the war. The regiment was ordered to be raised in January, 1846, and a nucleus of British officers and native ranks, drawn from units serving with the army in the field, was posted to it on paper. These individuals served in the field with their original units, but received their medal later on as the 11th Irregular Cavalry. Sir H. G. Smith's despatch written after the battle at Aliwal mentions a British officer of the " 11th Irregular Cavalry " who had been posted in orders to that regiment.

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Small *Native* detachments of the 4th Irregular Cavalry appear to have received the decorations for Moodkee and Aliwal. Faked clasps of this medal are *very* common; *e.g.*, "Aliwal" clasps are fraudulently added, or "Ferozeshuhur" or "Sobraon" clasps removed, in order to produce unusual combinations.

Medals were given to Prince Waldemar of Prussia and his suite, six in all (including two orderlies), who accompanied the Governor-General in the field as his guests; one of whom, Dr. Hoffmeister, was killed at Ferozeshah.

Officers of the Bengal Engineers who received medals for the Sutlej Campaign, 1845–6.

S. Lieut.-Colonel A. Irvine.
S. ,, , E. J. Smith.
S. Major F. Abbott.
S. ,, B. Y. Reilly.
S. Capt. W. H. Graham.
S. ,, W. E. Baker.
M.F.S. ,, R. C. Napier. (Wounded). Brigade-Major.
S. ,, J. W. Robertson.
S. ,, W. Abercrombie. (Wounded).
S. ,, H. Siddons.
A.S. Bt. Capt. J. D. Cunningham. (Political employ).
S. Lieut. J. Spens.
A.S. ,, R. Strachey.
A.S. ,, R. Baird Smith.
S. ,, A. D. Turnbull.
F. ,, A. G. Goodwyn. (With Littler's force).
S. ,, J. R. Becher. (Wounded).
S. ,, H. Yule.
S. ,, F. Whiting.
F.A. ,, E. J. Lake. (Wounded). (Political employ).
S. 2nd Lieut. W. D. A. R. Shortt.
M. ,, J. E. T. Nicolls.
A.S. ,, G. P. Hebbert. (Wounded).
S. ,, C. J. Hodgson.
S. ,, D. G. Robinson.
(F.) A.S. ,, A. Taylor.* (With Littler's force).
S. ,, G. Sim.
S. ,, C. S. Paton.

M signifies Moodkee.
F ,, Ferozeshah.
A ,, Aliwal.
S ,, Sobraon.

* Taylor received the decoration for Ferozeshah, as he was on duty in the Ferozepore Cantonment, but he was not present at the battle. In the same way many of the officers with A. or S. before their names were not actually present on the battlefields of Aliwal and Sobraon.

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TRANSCRIPT.

RECENT PROGRESS IN GAS-FIRE SCIENCE.

A Paper read by H. JAMES YATES, F.C.S., M.I.MECH.E., *at the British Association*, 1913.

THE coal fire is a heating contrivance which, however cheerful in appearance, does not, in its nature, make for great economy in the use of fuel. Yet the motive that gave rise to the introduction of gas heating as a substitute for coal heating was not economy but convenience, the question of economy came later. Considerations of hygiene and of greater thermal efficiency have come last in order and all three are now undergoing continual discussion, experiment, and development.

Utility being the first motive, the earliest gas fire, being intended to do the work of a coal fire, under conditions of greater convenience, was an imitation of the coal fire. It either occupied the fire space in the ordinary coal grate, or (more frequently) was placed within a similar cavity in a separate stove, which was set in front of the discarded coal grate. In either case, it consisted of a series of Bunsen burners, arranged along the front bottom bar, the flames of which played or impinged irregularly upon iron frets, wisps of asbestos filaments, or, more generally, perforated balls of refractory material, which were intended to resemble coal; these various refractory bodies were heated to low incandescence by immersion in the flames, after the gas had been lit for some time. This contrivance, whatever its convenience, resembled its prototype, the coal fire, in losing much of its heat up the flue, and in yielding only an irregular and inadequate return in the form of radiant heat from the fuel consumed. The improper way in which the flame impinged upon the refractory material also greatly impaired the completeness of combustion, a fact which not only involved waste of fuel, but was liable to occasion an escape of harmful combustion products into the room, especially when the chimney draught was poor, or the flue outlet of the gas fire badly constructed.

The gas-fire idea having been embodied in these early crude forms, it was gradually realized that on such a basis gas was no match for coal in point of cost, and the question of economizing devices came to the front. The manifestly great flue losses led to the heat-economizing efforts being all directed towards delaying the escape of the combustion products until they should have communicated

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as large a proportion as possible of their sensible heat to the body of the stove, to be afterwards transmitted into the apartment in the form of hot-air currents from the stove body. In other words, these early efforts in gas-fire economy aimed at *concentrating on convected heat.*

A shape which these convection devices usually took was the forming of chambers in extended flues within the stove body. The hot combustion products on passing through these chambers or flues, imparted most of their sensible heat, by conduction through the walls, to currents of cold air from the room, which thus became warmed by passing over the outside of the walls of these chambers, and which issued therefrom as hot-air convection currents into the room through perforations provided for the purpose. But the heat economy thus realized was accompanied by a bad physiological effect, inasmuch as the convection currents leaving the stove were so hot that the dew point of the air of the apartment was unduly raised, and its degree of saturation lowered ; the skin and the mucous membranes of the throat and nasal passages of the occupants offering ready sources of moisture, " dry " sensations, prickling of the skin, and other disagreeable symptoms were complained of. Anyone entering a room so heated could generally " smell the gas fire," as it was expressed, partly owing to the cause already mentioned, but perhaps more to the escape of products of combustion into the room, through faulty construction of the stove, and to the burning of dust by contact with the overheated " convecting " chambers of the stove. Further, owing to the air of the room being hotter than the walls, persons sitting near these, while feeling discomfort owing to the overheated air, might yet experience chilling sensations owing to radiation from their bodies to the cold walls. These drawbacks engendered a widespread prejudice among the public and the medical profession against gas fires.

It was the personal discomfort which such stoves occasioned to myself that led me to take up the matter and endeavour to devise a new type of gas fire free from these defects. Even after my work in this direction had made substantial progress, it was most difficult to get the public to grasp the real causes of the discomforts then attendant on the use of a gas fire, and it was no speedy or easy task to educate them to realize that such troubles were not inherent in the gas fire as such, but that they were merely evils inseparable from the mistaken practice of " high-temperature convection " in moderate-sized apartments, whatever the source of heat. A general impression prevailed that in some mysterious way gas used for heating must necessarily produce disagreeable effects from which a coal fire is free. It was overlooked that the combustion of coal is after all to a large extent the combustion of coal gas, and that whereas the coal fire produces and burns crude gas with all its native impurities unremoved, the gas fire burns a concentrated and purified gas. It was not realized that nothing can arise from the combustion of coal gas that does not also arise from the combustion of coal, and that, therefore, any ill-effects associated with the use of the earlier crude gas fires cannot be rightly ascribed to the *nature*

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of gas heating, but must be due to some radical fault in the *methods* of applying it.

This being so, I realized that the only way to remove the popular prejudice was to remove its cause. First of all, it was clear that the temperature of the convection currents ought to be reduced so as to effect a corresponding reduction in the moisture-absorbing capacity of the air of the room. It then occurred to me that the old idea of enhancing the total heating efficiency of the fire by increasing the "*convected*" heat effect in the manner described was a mischievous one and the source of all the trouble; and that the true remedy must be sought for in increasing the "radiant efficiency" of the fire to the maximum possible with consequent decrease in the amount of "convected" heat.

The known advantage of radiant heat being that it warms the walls, the furniture, and the occupants of the room rather than its atmosphere, the problem was how to increase efficiency in the direction of radiation so as to compensate, both in heating power and in economy, for the reduction in the temperature of the convection currents. The gas fire, which hitherto has been a haphazard evolution from the coal fire, now became the subject of a reasoned and drastic revolution. The convection chambers were dispensed with. The deep fire chambers became a shallow space in the front of the apparatus, its depth only that of one piece of refractory material. The erratic arrangement of fireclay lumps was superseded by placing two or three such pieces one above the other exactly over the flame, so as to form an envelope for it. A little later a more marked step in the evolution of the new radiating fire consisted in joining the two or three fireclay pieces into one, and thus making the fire front consist of a series of hollow fireclay columns (now known as radiants), perforated in a design expressly contrived to promote uniform heating of the column throughout, and with each flame rising into the cavity of its radiant. Care was taken to prevent any impingement on the inner cone of the flame; by this means, and also by using a correctly designed burner, and making due provision for the proportionment of the gas and air supplies, perfect combustion was ensured. A further important improvement was the dispensing with the cast-iron front bars hitherto used to retain the loose fireclay lumps, and the replacing of these bars by one slight horizontal rod. This arrangement not only left no obstruction in the path of the radiation, but vastly improved the appearance of the fire. The effect of these radical changes has been that the greater proportion of the energy developed by the combustion of the gas around and in contact with the radiants is transmitted into the apartment as radiant heat. This radiant heat quickly makes its warming effect felt by the occupants; yet, inasmuch as it passes through the air without sensibly warming it, the discomforts formerly occasioned by the now discarded "convection" methods are at an end. The walls and the objects in the room, becoming warmed by absorbed radiant heat, no longer abstract heat from the occupants, and further, they gradually warm the air to a moderate degree by convection currents which, being necessarily at a low temperature,

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do not reproduce the former excessive moisture-absorbing condition of the air.

This gradual warming of the air by contact with the objects in the room naturally cannot begin for some little time after the fire has been lighted, not indeed, until the radiant heat of the fire has warmed the walls and furniture. From the outset, however, there is a certain proportion of convected heat from the stove (but at a low temperature, owing to the absence of the old special heating chambers) and this primary or direct low-temperature convection at once begins to gently raise the temperature of the air, thus anticipating—and later on co-operating with—the secondary low-temperature convection from the walls and furniture, in suitably warming—but not overheating—the air. It will thus be seen that although the earlier types of gas fire may have made their heating effect more quickly apparent, yet in the gas fires of to-day the primary convection is also doing its work from the first, though in a less conspicuous and more healthful way. In this way radiation has taken the place of convection as the mode of heat transference principally aimed at in gas-fire design.

Having thus traced the evolution of the modern gas fire, I come next to that on which the modern gas fire so largely depends, viz., radiation, to the problem of increasing which, much research has been devoted. Progress towards higher radiant efficiency in a fire can be measured only when a reliable method of estimating the latter is available. The present accepted method is that adopted by the Joint Committee appointed in 1907 by the Institution of Gas Engineers and the University of Leeds, for the Investigation of Gas Fires; this method, which was originally suggested to the Committee by Professors W. A. Bone and William Stroud, is essentially a radiometer-*cum*-thermopile method. Part of the radiant energy is directly determined (in kilogram centigrade units) by using a radiation calorimeter (or radiometer), and the remainder by means of a thermopile and galvanometer, standardized against the radiometer for each experiment. A full description of the method was included in the Committee's First Report as published in *Trans. Inst. of Gas Engineers*, 1909. Various other methods have been suggested, both electrical and calorimetrical, but so far as I am aware, no authoritative vindication of their reliability has as yet appeared. The most recent suggestion, viz., that of a calorimeter, to absorb all the radiation from a fire, fails for one or other of two reasons. In the one case, if it be larger than the fire, then the water capacity becomes very great, and difficulties occur in ensuring perfect circulation, also heat is lost from the outer surface by convection and radiation. Alternatively, if the instrument be so small as to necessitate its being placed very close to the fire, the free access of air to the fire is interfered with, thus upsetting the natural action of the air currents and setting up abnormal conditions.

The testing of gas fires is a much more difficult matter than might be imagined. Considerable experience in heat measurement is called for, and until recently this has not been available in commercial testing laboratories, and even now the number of trained workers who have

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turned their attention to this branch of research in connection with gas fires is very limited. And in the absence of such special experience, results obtained even by otherwise careful and competent workers are of doubtful value, owing to unsuspected errors in judgment or inherent defects in the methods employed.

Manufacturers of gas fires are under a great obligation to the scientific work organized and carried out under Professor Bone's supervision at Leeds University, by the Joint Committee appointed by the University and the Institution of Gas Engineers, which has greatly stimulated further enquiry on the part of manufacturers.

Ten years ago even the best deep fires did not afford more than 30 to 33 per cent. of the net heat of combustion of the gas in the form of radiant energy. In the effort to secure increased radiation (by which I mean a higher percentage of the heat developed by the combustion of a given amount of gas delivered as radiant energy) it has been found, as was to be anticipated, that to advance from these low figures to 45 per cent. is much more easy than to make a further increase above 45 per cent. The adoption of the shallow-fire principle, and the dispensing with the front bars, to which I have already referred, was responsible for an increase from 30 per cent. to somewhere about 42 per cent. From that point, by attention to the perfecting of the design and proportion of the burners and back-bricks, and—most important of all—that of the radiants, we have been successful in further raising this figure to 48—50 per cent., and indeed, in some instances, to as high as 55 per cent.

From the first, gas fires had been made considerably smaller in width than the average coal fire, and when the new shallow-fronted radiation gas fire had been evolved, there still remained a general tendency to keep these fires down to a similar narrow width, the impression probably being that inasmuch as gas fires give a more concentrated heat, a smaller fire space was adequate. I became convinced, however, that if gas fires were to take the place of coal fires for heating the largest domestic apartments equally well as the smallest, it would be necessary that gas fires should be made available having a fire space as wide as that of the coal fire. Although this development was simple in appearance, it involved constructional problems which were only solved after considerable experiment; the result has been that gas fires of the new type are now made as wide as 17 in. and 21 in., fires of that size being capable of heating rooms up to a cubical content of at least 4,000 cubic ft.

The problem of total heating efficiency is, however, not the only one which makers of gas fires have to solve; the equally important question of ventilating effect must also be considered, for a properly constructed gas fire should effectively ventilate as well as heat an apartment. It is obvious that no fire could be considered as hygienically perfect, which, when connected with a chimney flue in the ordinary way, and subjected to a moderate chimney draught, allows any products of combustion to escape into the room; but provided that this elementary hygienic requirement is fulfilled, the question of "hygienic efficiency" resolves

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itself into the amount of excess air over and above that required for combustion, which can be drawn up the flue per cubic foot of gas burned, when the fire is so connected and fixed. There is obviously no object served in testing or discussing "hygienic efficiency" or "ventilating effect" except in relation to conditions of ordinary chimney draught, because no gas fire ought ever to be used except it be connected with a chimney or flue leading into the outside atmosphere.

It is not difficult to design and proportion the flue vent and the canopy of a gas fire so as to ensure the drawing up the flue of a large volume of air, thus producing good ventilation. The real difficulty is to avoid drawing this large excess of air over the upper portion of the "radiants," thus cooling them and unnecessarily diminishing the radiant efficiency of the fire. In other words, whereas it is comparatively easy to achieve "ventilation" at the expense of "radiant efficiency," a really scientifically constructed fire should ensure an equally good "ventilation" without sacrifice of radiant efficiency, which although not so easy, is by no means an impossible matter.

In this connection, my own researches have convinced me of the importance of preserving a certain adequate vertical distance between the top of the radiants and the bottom of the canopy of a gas fire, so as to avoid drawing the induced "ventilating" air over the upper portion of the radiants; experiment has proved that such a constructional feature, combined with an adequate flue vent, ensures a much higher radiant efficiency than another type (in point of fact older, but which it has been recently sought to revive), in which the canopy is brought down to overlap (or nearly so) the top of the radiants. As the relative merits of these two types of construction have recently been under discussion, it may be of interest if I append the results of an investigation of the matter in my own laboratory, which seem to prove conclusively the marked superiority of the first-named type of construction.

To ascertain the total heating efficiency, each type of construction was tested by determining the radiant efficiency, using the Leeds University method, and at the same time determining the amount of heat lost through the chimney flue. The total of these two, deducted from the heat developed by the combustion of the gas, gives the amount of convected heat. It is obviously impossible to estimate directly the convected heat, since the radiant energy also eventually makes itself sensible in this form.

The fires were tested under a series of parallel conditions. In the first case, the flue outlets were blocked up; this neutralized any possible cooling action of the flue draught on the radiants. The second test was one with the flue outlets open. In the third the two stoves were connected to a chimney. It ought to be remarked that changes in the meteorological conditions sometimes influence the amount of air withdrawn from the room by a given chimney to a surprising degree.

It will be seen from the figures that the lowering of the canopy, as had been anticipated, resulted in a lowered radiant efficiency and a

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lowered total heating efficiency, due to the cooling influence on the radiants of the air drawn over them.

In concluding, it should be stated that the entire change in the construction principle of gas fires which has just been described, has led to an equally great change in the attitude of the medical profession and the public towards the use of gas for heating. As a result there are to-day upwards of 350,000 gas fires in use in London alone, and there is every indication that each succeeding year will see a further substantial advance in the adoption of this method of domestic heating in preference to the coal grate, which has for so long been the chief and almost the only means available for the purpose, and that thus the atmosphere of large towns will become increasingly clear through the smokeless nature of gas-fire combustion.

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TABLE ILLUSTRATING INFLUENCES OF INCREASED DRAUGHT THROUGH A LOW CANOPY.

Fire.	Consumption at N.T.P. cu. ft. per hour.	Nett Cal. Val. K.C.U. per cu. ft.	K.C.U. Developed by Gas.	K.C.U. Radiated.	Flue Outlet.	Percentage of Nett Heat of Combustion. Radiated.	Removed by Flue Gases.	Convected.
Canopy well above radiants as described.	24·15	144·8	3496	1730	Blocked up	49·5	—	—
	24·75	143·6	3553	1710	Open but not connected to chimney	48·1	27·2	24·7
	25·24	143·3	3617	1730	Connected to chimney	47·8	30·8	21·4
Canopy brought down to top of Radiants.	24·73	144·7	3578	1562	Blocked up	43·7	—	—
	24·17	145·7	3522	1373	Open but not connected to chimney	39·0	36·6	24·4
	23·77	146 9	3493	1223	Connected to chimney	35·0	42 0	23·0

TABLE SHOWING EFFICIENCY RESULTS OF DIFFERENT SIZED MODERN FIRES ATTACHED TO A CHIMNEY 30 FT. HIGH, THE CANOPY IN EACH CASE BEING WELL ABOVE THE RADIANTS—AS DESCRIBED.

Fire.	Consumption at N.T.P. cu. ft. per hour.	Nett Cal. Val. K.C.U. per cu. ft.	K.C.U. Developed by Gas.	K.C.U. Radiated.	% CO_2 in Flue Gases.	Temp. of Flue Gases.	Percentage of Nett Heat of Combustion. Radiated.	Removed by Flue Gases.	Convected.
10"	25·24	143·3	3617	1730	·90	117°C.	47·8	30·8	21·4
14"	34·02	145·5	4950	2490	·80	104	50·3	30·7	19·0
17"	42·62	143·2	6102	3003	·93	109	49·2	29·4	21·4
21"	52·90	144·8	7661	3903	·77	101	51·0	26·4	22·7

NOTE.—The consumptions shown above are somewhat higher than is necessary in general practice. They were determined by the type with lowered canopy which required more gas to make the radiants incandescent to the top.

In arriving at the above figures for percentage of heat radiated, it has been thought necessary to make a correction, during the radiation determination, for the convected heat which is absorbed by the Radiometer, and which would otherwise figure as radiated heat. This correction is not specifically mentioned in the Report of the Committee which first investigated and used the method at Leeds, and but for this correction the percentage of radiant heat would stand approximately five units higher in each case than the above figures.

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NOTICE OF MAGAZINE.

Revue d'Artillerie.

May and June, 1913.

Can the Enemy's Artillery be Destroyed?

By C.D.—Destruction can be of two degrees, the *personnel* can be killed, or the *matériel* destroyed, and the latter must necessarily include the former, since the case of detachments leaving their guns is unimaginable. The regulations admit the destruction of the *matériel* as possible, without excessive expenditure of ammunition, if the range is not too great—say 2,000 to 2,500 metres. With guns in the open this may be considered a certainty, but to reach batteries of which the locality is unknown, either because they have not yet fired, or because they are only betrayed by sound, shell with time fuze distributed over a wide and deep zone is necessary. It is hardly likely that the density of this fire will cause serious damage, but such concealment is not often obtainable; flashes, smoke, or dust will generally betray the position.

It seems certain then that although the whole of the enemy's artillery cannot be silenced, still the detachments of all guns in sight may be killed and many of the guns destroyed and 30 to 90 per cent. of losses inflicted on batteries of which the direction only is known.

This result will be contested, and will not be gained without loss. Without false shame the expression "artillery duel" must be readopted. In this duel one side will inflict on the other greater losses than it has itself suffered, still in the latter some few guns will be available up to the moment of the assault. It is to be hoped that this will be on the enemy's side, and that the very concealment that has saved the guns may render them less dangerous at the critical moment.

Talks on Artillery.

By Major P. Muller.—Contains hints to artillery majors in regard to the training of their batteries, the results of personal experience. The following heads are discussed:—(1). General observations on taking up positions. (2). The use of maps divided into squares. (3). Choice of observing stations. (4). Watching the progress of events in the field. (5). Use of telephones. (6). Firing over the heads of one's own troops. (7). Problems connected with masked positions. (8). The issue of orders, including the reconnaissance to be carried out by the Major whilst the batteries are being lead to their positions.—(*To be continued*).

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ORIENTATION BY MEANS OF THE SUN.

By Lieut.-Colonel J. Favret.—A glance at the sun is quicker than having to stop to use a compass. The article is accompanied by diagrams showing the hours at which the sun passes the cardinal points of the compass for the principal epochs of the year at Chalons and Fez (Morocco). These diagrams are sufficiently accurate for any point within 4 degrees of latitude of these towns. For differences in longitude it is necessary to add or subtract as many times four minutes as there are degrees of difference in longitude.

THE ESSENTIALS OF A RANGING APPARATUS.

By Capt. E. Bourboulon.—The *lunette de batteries* carried with the 75-m.m. gun only imperfectly fulfils requirements. The Rimailho theodolite carried in 155-m.m. batteries allows of all problems connected with ranging to be satisfactorily solved. The German *Nichtkreis*, mounted on a metallic stand, and provided with a compass, acts on the same principles. Recently a field telemeter has been tried and attempts have been made to add to it an instrument for measuring angles, but the combination contains no compass. Whatever may be the position of the observing station with reference to the battery, the instrument should allow of the line of fire being obtained by some simple operation, if possible before the arrival of the battery. There should be two instruments with each battery. It should be extremely portable and easily set up and adjusted. A compass should be attached.

THE GERMAN FIELD ARTILLERY PRACTICE CAMPS OF 1912.

Translated by Capt. G. Rogers-Vasselin.—The reports of the practices carried out in 1911 and published in the *Artilleristische Monatschafte* showed that the Germans are closely copying French methods of ranging. The 1912 reports show that they are still in the period of trials that the French have completed long ago.

The article is interesting as showing the German progress in the art of manœuvring and employing field artillery, and contains some useful suggestions for overcoming the usual difficulties.

UNIVERSAL SHELL.

By Capt. H. Peloux (*continued from the April number*).—3rd Group, detonating charge in the head. To this group belong the most recent and most perfected shells, and to it, or to the 4th group, will probably belong the shells of the future.

The following are described and illustrated :—Sokolooski's improved shrapnel, 1888. The double action shell of Daniel van Essen, 1903. Bursting shrapnel by the same, M/1906, M/1907, C/1910. The German light howitzer shell, but very little is known of this. Puff's shell, 1906. Keller's shell. Schneider's shell.

The general principle of this group is to keep the common shell portion in front. The rear, or shrapnel portion, with bursting charge in the base, can be burst with time fuze, when the front, or shell portion, continues its flight in practically the same trajectory with nose to the front. The bullets are surrounded with trinitro-tolnol or other explosive, which merely burns away when ignited by the time fuze. If the front

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portion separates easily, the cone of dispersion of the bullets is not unduly opened, and the front portion has sufficient residual energy to pierce the shield of a gun and burst on impact, or immediately in rear of the shield, under the action of a percussion fuze which may be set with or without a delay action. In some models a smoke-producing composition enables the burst to be observed separately from that of the shrapnel portion. Against obstacles or fieldworks the whole shell bursts practically simultaneously under the action of the percussion fuze, the trinitro-tolnol of the shrapnel portion being detonated in this case.

The 4th group contains only the most recent models of Krupp's shells. In one the shrapnel portion is in the head and the shell portion in the base, but it is probable that the explosion of the shrapnel would cause the base to diverge from its course, at any rate its penetrative power would be small. In a second model there are four charges, the shell portion being in the head. When the shell is fired with time fuze as shrapnel, the head carries with it, besides its own charge, a second attached to it by a small thick walled cylinder. This cylinder is intended to steady the head in its flight, as well as to add to the destructive effect of its explosion. When fired as shell with percussion fuze all the charges detonate simultaneously.

Many of the shells described have not been constructed, and the results of trials of others are secret. The last models of Erhardt & Krupp, however, have been frequently tested, and the results are known. When fired as shrapnel with time fuze it appears that the results are just as good as with the old ammunition, provided the aim is so good that the shell portion reaches the target as well as the shrapnel. Against troops in the open, therefore, the result is slightly inferior, as the shell portion makes a fougasse, and many fragments are buried in the ground. Against the *personnel* of artillery in blinded cover the universal shell is far superior to shrapnel, for in both cases the shrapnel bullets are ineffective, but in the former the head penetrates and bursts among the detachment. The effect as shrapnel might be increased by arranging, after the bullets have been discharged, to shatter the envelope, so that the fragments may be added to the bullets. Puff's model realizes this idea.

Used as explosive shell against troops in shelters with percussion fuze, a well-aimed shot is very deadly, as the shrapnel bullets are added to the fragments of shell. With time fuze the universal shell has, for similar reasons, more effect than the old explosive shell, but against artillery in covered positions, and leaving out of account the few direct hits, it is better to fire the shell as shrapnel with time fuze than as shell with time fuze. In the latter case the whole shell explodes at once, but in the former the head goes out and bursts on or behind the shield, putting the detachment *hors de combat.*

It appears paradoxical, but, owing to the fact that the shrapnel bullets of the universal shell are surrounded with trinitro-tolnol, these shell actually contain more high explosive than the ordinary common shell, and as the effect against resisting objects depends on the amount of explosive, the new shell are more effective than the old, especially when the percussion fuze is filled with a delay action.

In an appendix are given in tabular form the results of certain experiments.

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VARIOUS INFORMATION.

An automatic alarm for telling when a crane is overloaded is described, and is the invention of Philip F. Felice, of Brussels.

A note is given on Bernard's planimeter, which is said to be good and cheap. Its box contains tables by which areas shown on various scales can be readily found.

A short description, with photograph, is given of the Krupp 28-c.m. howitzer, mounted on travelling carriage. The wheels can be filled with wide plates to prevent their sinking into even soft ground. Elevation can be given from + 20° to + 65°, and training 5° on each side of the centre. The shell weighs 750 lbs. and contains 38 lbs. of explosive. There are eight charges, the muzzle velocity ranging from 180 to 340 metres a second. The maximum range is 10,100 metres.

In Germany certain cast horses are retained with their units for duties in barracks, and their rations are paid for from a special fund. In consideration of a payment to this fund officers can use them for going to barracks, rifle range and other military duties.

In Switzerland a form of man-harness is being tested, for moving guns in action. The German field gun and light howitzer are provided with drag-ropes. In France man-harness is issued to the 75-c.m. field gun.

July, 1913.

ARTILLERY IN THE GRAND MANŒUVRES.

By "C.D.," who suggests reducing the numbers of guns on these occasions from four to two per battery. This would enable men to be found for staffs, scouts, and communication services, a thing impossible at present. Of the two wagons with these guns, one would represent the first line, and the other the second. The spare teams and drivers, etc., could be utilized as additional scouts, artillery park with the *corps d'armée* and so on. Discussion of this suggestion is invited.

THE EVOLUTION OF MOUNTAIN ARTILLERY.

An interesting article by Capt. L. Amene, of the Colonial Artillery, and well illustrated. After a short historical sketch, the undermentioned are described :—Krupp's guns varying from 40 m.m. to 76·2 m.m., and the mountain howitzer of 100 m.m. Erhardt's guns of 1906, 1907, 1909 and 1911 with special mention of the *canon puissant* L. 19, M. 1911, and the mountain howitzer of 105 m.m., L. 12, M. 1912. The guns of Skoda, Vickers-Maxim, Deport, Saint Chamond and Schneider. The results of certain experiments with the last named are described. The conclusions he arrives at are that six mules and no more should be capable of carrying the gun and its carriage, cradle, buffers, etc. 75 c.m. (3 in.) is a good average diameter for the bore, 6½ k.g. (14¼ lbs.) a fair weight for the projectile, and 350 metres a second a satisfactory muzzle velocity. The article is accompanied by tables comparing the characteristics of the principal guns, their ammunition, etc.

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Talks on Artillery.

This article is continued and suggestions are made in regard to :—

IX. Ranging on crests.
X. Firing into the dead ground in front of the mark.
XI. The use of aiming posts.
XII. Ranging on puffs of smoke with the help of the compass.
XIII. Firing on flashes.
XIV. Firing on slopes descending towards the observer.
XV. Neutralizing fire.
XVI. How to discover when an effect has been produced on artillery that cannot be seen.
XVII. Distant fire.
XVIII. The range that should be given by the gunner to the infantry soldier who asks this information.
XIX. Procedure to be adopted if the corrector readings are surpassed during ranging.
XX. Fire against swarms of infantry in small distinct bodies.
XXI. Firing against woods.
XXII. Firing against towers.

The Chatillon-Panhard Tractor.

A good description of this motor, accompanied by several photographs and a plate of diagrams, is given by Commandant L. Ferrus. Increased power is obtained by using the front wheels as driving wheels, as well as the hind wheels. This necessitates also using the hind wheels for steering. The transmission is very ingenious and has been found very successful. The writer considers this tractor an ideal motor for military purposes ; the results obtained were extraordinarily good.

Various Information.

A short description is given of the German 13-c.m. (5·12-in.) siege gun.

Alexander Humphrey, an American, has invented a " torpifying bullet " for rifles, which he claims as an eminently philanthropic invention.

The United States have produced a comparatively cheap target representing an electric light projector, against which their artillery can obtain the practice indispensable for hitting such objects.

The Dutch are experimenting with powders that produce no flash. These are of local and of German manufacture.

August, 1913.

Note on the Effect of Wind on a Moving Body.

By P. Charbonnier, Chief Engineer of Naval Artillery.—The usual formulæ being derived from the consideration of weights concentrated at a point, take no account of the shape of the body. This the writer proceeds to do, studying the cases of transverse and head winds. With side winds, the longer the body (or projectile) the greater the lateral deviation, which is also considerably affected by the shape of the head. With a head wind the shape makes very little difference to the range.

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RANGING APPARATUS OF THE GERMAN 96-M.M. GUN.

By G. Roger-Vasselin, Capt. of Artillery.—These apparatus form two distinct groups. The older group comprises the hausse-niveau (Libellen-Aufsatz) with telescope (Visierfernrohr) and level (Libelle).

The dial sight (plaque de repérage) (Richtfläche).

The aiming post (jalon de repérage) (Richtlatte).

The clinometer (cadran de pointage) (Winkelmesser).

The newer group consists of the panoramic sight (Hausse panoramique) (Rundblick—or Panorama fernrohr).

The director with compass (Cercle de pointage) (Bussolenrichtkreis).

The lunette à ciseaux (Scheren fernrohr).

The article is well illustrated with photographs and diagrams.

A. *1st Group.*—These instruments are well known, and details can be obtained from the French or German publications describing them. A short description of each is, however, supplied.

B. *2nd Group.*—This group consists of appliances more especially suited for indirect laying. The ordinary sight can be also used for this purpose, but its range is limited by the narrowness of the opening in the shield.

The 1903 model of the panoramic sight was described in the *Revue d'Artillerie*, Vol. 62, p. 127, but many improvements have been introduced recently. It appears to be very similar to the British panoramic sight, and can be used on the gun for direct or indirect laying, or on a tripod, or fixed to a shield, in any convenient position for examining the objective and the results of fire. The instrument issued for normal use for the latter purposes, however, has smaller magnifying power and a wider field of view than that used for sights. Those for the guns are carried in a box on each gun, that for observation on a wagon, and is fitted with a strap for carrying over the shoulder when required. All field batteries will shortly have this instrument issued to them.

The director was originally a semi-circular dial sight, but has been improved by the base plate being made a complete circle and by the addition of a telescope and of a magnetic compass. The base plate is graduated in millièmes (6,400 to the circle). The angle of site can also be read, the instrument being provided with a spirit level and a vertical scale for this purpose. It is mounted on a tripod capable of considerable adjustment for steep slopes. The instrument and its uses are described. If the target and the battery are not both visible from the observing station two instruments are required, and even with telephonic communication between them both and the battery it takes 20 minutes to make the observations and communicate the results so that ranging may begin.

The lunette à ciseaux (Scheren fernrohr) is used in the same manner as the cercle de pointage, except that having no compass it is of no use for ranging when the battery cannot be seen from the observing station. It consists of a stereoscopic arrangement of telescopes movable on a vertical pivot over a horizontal base plate. The two eye pieces are fixed to the pivot, and tubes and object glasses can be elevated to observe over a shield or screen, the observer remaining hidden, or depressed to

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the horizontal. In the latter case the object glasses are about 1 metre apart and the definition is excellent. In open positions the cercle de pointage would generally be used, as it is more easily manipulated, but in covered positions the lunette is better as the observer need not show himself. Both instruments are carried in the observing wagon, but can be withdrawn in their cases and carried in a special fitting on a saddle.

The Part Played by the Artillery in the Battle of Vietrissa on 10th July, 1913.

By Major De Poilloüe de Saint Mars, of the Artillery.—In a recent article in the *Revue d'Artillerie* General Herr advocated the necessity for long-range guns, but it does not follow that a combatant must be reduced to silence if not in possession of such weapons. Battles are not won at long ranges, and field artillery can be usefully employed within their own range (5 k.m. or less) if carefully manœuvred out of sight of the heavier guns. When there, their superior rapidity of fire, their numbers, and their accuracy may overpower the heavier weapons. This was exemplified at the Battle of Vietrissa. Beaten at Denier Hissar and Doiran the Bulgarians retired behind the Stroumar, and took up a position with their heavy guns, which carry 9 kilometres. The Greeks had no long-range guns, and their advance was checked, but under cover of night they advanced their field artillery so close to the Bulgarian heavy guns that they were able to reduce them to silence. The Greek infantry then advanced, accompanied by mountain artillery, and the Bulgarians had to quit their position in haste, abandoning their heavy guns and several field guns.

Corrections to the German Field Artillery Manœuvre Regulations.

Since the last issue (1907) of these regulations about 200 correction slips have been issued, which can be divided into three series. The first, issued between 1909 and 1911, apply to the foot artillery. During this period fixed ammunition was introduced, the director replaced the dial sight, and aiming points and indirect fire were developed. The second series (1912) dealt with the mounted artillery and the 1913 series comprises a new edition of Chapter II.—foot artillery—and is only applicable to those units to which the panoramic sight has been issued.

Except as above the alterations are slight; the more important are as follows:—In the first series the salvo is omitted. In firing over friendly troops percussion fuze is to be substituted for time fuze when the first line reaches 300 yards from the enemy; the elevation is then raised to hinder the approach of the reserves. On the defensive, when the field artillery must come into the open to oppose the advancing infantry, the heavy artillery will, as a general rule, continue to fire on the enemy's artillery.

The second series includes orders for the observatory waggon, the semi-covered position is done away with, the position in observation is substituted for the position in readiness, and stress is laid on the necessity for obtaining concealment from the enemy's aircraft. The destruction, and not only the neutralization of the enemy's artillery, is enjoined,

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fresh orders are issued in regard to the duties of the artillery commanders, and considerable modifications are made in regard to acting in conjunction with the infantry. The important point is to liberate as soon as possible the mass of the field artillery to employ it against the enemy's infantry.

The most important of the 1913 series are those dealing with the supply of ammunition. It is laid down that if clear observations can be taken, the friendly infantry can advance to within 200 metres of the point of impact of shell fired with time fuzes, and 150 metres if percussion fuze is being used.

THE WINCHESTER SPORTING RIFLE, MODEL 1911.

This rifle is described and illustrated by a plate with several diagrams.

VARIOUS INFORMATION.

Contains a short description of the German observatory wagon and its contents. Its issue was not, at first, hailed with acclamation, but its uses are now well recognized.

A short description is given of the German 10-c.m. gun, M. 1904, also of the German 21-c.m. mortar battery.

September, 1913.

STUDY OF THE CUTTING PROPERTIES OF TOOL STEELS.

By P. Denis, Capt. of Artillery.—A tool steel is a steel hard enough to cut all metals, but the hardest steel is not necessarily the best for tools. It must also possess toughness. Tool steels can best be classified by their output, *i.e.* by the volume of metal which they will remove in a given time before becoming so blunt as to require re-sharpening. The machine invented by Mr. E. Herbert of Manchester is the best for measuring this output, and is described and illustrated by diagrams.

The aim of this article is to study the cutting properties of tool steels according to the thermic treatment they receive during manufacture, and to deduce from this the best processes to subject the steel to, in order to obtain suitable qualities for the various requirements of a machine shop.

The article is clearly written and is interesting.—(*To be continued*).

EFFECT OF THE RECOIL OF A GUN ON THE STABILITY OF AN AEROPLANE.

By Capt. A. Alayrac of the Artillery.—The probable effect is worked out theoretically, by the aid of the higher mathematics, for a gun recoiling with a force of 700 to 800 k.g. in a space of ·05 second. The results deduced are that such a gun may be placed anywhere within 1 metre of the centre of gravity of the machine without exerting a seriously disturbing effect, but that it would be prudent to arrange for the centre of rotation to be as near as possible to the transverse axis of inertia.

MECHANICAL FUZES.

By Capt. C. Roger-Vasselin.—In this article it is proposed :—

(1). To point out the reasons calling for the replacement of combustion fuzes by fuzes of purely mechanical action.

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(2). To classify the various types of fuzes now existing.

(3). To study briefly each of the groups, selecting in each its most characteristic examples.

(4). To study, independently of the general classification, certain details such as safety appliances, etc.

The combustion fuze is considered to be doomed. It is very large and heavy, and its rate of combustion is altered by prolonged storage, and even varies from day to day owing to differences of atmospheric pressure.

Fuzes may be classified as follows :—

(1). Those depending for their action on the inertia of some part of the mechanism, or on the resistance of the air.

(2). Those depending on the flow of a liquid.

(3). Clockwork fuzes.

The principles of the first group are described, and a long list of makers is given. Among these the fuzes of Berdan, 1880, Neesen, 1885, Mieciche, 1885, Nordenfelt, 1890, Ludra, 1892, were described in the *Revue d'Artillerie* of September, 1895, by Capt. Bloch. Those of Keeson, 1894, Merek, 1900, MacEvoy, 1898, and Mauberge, 1895, are here described and illustrated. Compared with those of the second and third groups they are inferior, owing to the irregularity of their action. This is partly inherent to the design, and partly owing to the varying velocities of revolution of different projectiles. The former defect cannot be overcome, and it appears practically that the latter can only be obviated by making a different fuze for each type of gun, and even for the same gun if it is fired with varying charges. In this respect the interchangeable combustion fuze has a decided advantage. Again, the pendulum, or vane, if projecting outside the fuze, has to be removed for transport, which leads to waste of time in refixing it when the fuze is to be used. These fuzes are, therefore, of little practical use.—(*To be continued*).

The Webley-Fosbery Automatic Revolver.

A description of this revolver is given and illustrated by a plate containing 10 diagrams.

Various Information.

Contains a list of patents, mostly German, and specifications of projectiles designed for firing against balloons and dirigibles. These are either incendiary shell, or are intended to tear large holes in the envelope, and resemble the old chain-shot.

A short description is given of the German heavy 15 c.m. (5·9 in.) howitzer M. 1902.

October, 1913.

Trinitrotoluine.

A description is given of the composition, manufacture and chemical and physical properties of this explosive.

Mechanical Fuzes.

This article is continued with descriptions of the fuzes in the 2nd and 3rd groups. As examples of the 2nd group the fuzes of Tremel (1865) and Smith are explained and illustrated, and of the 3rd group

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those of Hanel (1895), Baker (1904), Schneider and Krupp. The author's conclusions are that the clockwork fuzes have considerable advantages over the others from the points of view of size, weight, keeping properties, ease of manipulation and regularity. They are practically a necessity for long range guns, as the size of the ordinary combustion time fuze becomes far too great.—(*To be continued*).

CUTTING PROPERTIES OF TOOL STEELS.

This article is continued, and is accompanied by various diagrams showing the relations between the output and the rapidity of stroke for different qualities of steel, so-called "power curves," and curves of output with and without a liquid (oil or water) to cool the tool. The hardness and toughness of a steel varies with its temperature; the toughness first diminishes as the temperature rises, and then increases again at higher temperatures. Similarly the hardness first diminishes and then increases. The greatest output is obtained when the cutting edge attains a temperature at which the hardness and toughness are both maxima. Some steels give their maximum output at two different temperatures, separated by a critical temperature at which the output is low. If the tool passes the critical point without being blunted it will continue to give good results at the higher temperature without further sharpening. The temperature of the cutting edge depends on the rapidity of the stroke, the depth and width of the cut and the hardness of the metal to be cut, and the best temperature to work at can be determined by Herbert's machine. The article is clearly expressed, and would be of great interest and value to anyone engaged in manufacturing operations involving the use of steel tools for shaping metals.—(*To be continued*).

VARIOUS INFORMATION.

Italy, Reorganization of the Artillery.—The reorganization decided upon in 1910 brings the strength to:—

36 regiments of field artillery (12 corps and 24 divisional)=193 batteries, 36 depôt batteries, and 36 train companies.

2 regiments heavy field artillery=20 batteries and 2 depôt batteries.

1 regiment horse artillery=8 batteries, 1 depôt battery and 4 train companies.

2 regiments mountain artillery=24 batteries and 2 depôt batteries.

10 regiments fortress artillery=98 companies and 10 depôt companies

An addition of 19 regiments in all, of which the raising of six only is immediately ordered.

A Royal decree in 1911 also added 10 groups (each of 3 batteries) to replace a part of the units sent "provisionally" to Tripoli.

Adding the figures for increases in the infantry, cavalry and engineers this amounts to the creation of a new *corps d'armée*.

England—Tetranitaniline.—The composition and characteristics of this explosive are shortly described, and it is compared in tabular form with gun-cotton, picric acid and trinitrotolnol.

Germany.—A short notice is given of illuminating and incendiary shell.

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THE TACTICS OF DIVISIONAL ENGINEERS.

By LIEUT.-COLONEL F. E. G. SKEY, R.E., *Commanding Divisional Engineers, 6th Division.*

MANY hold the opinion that the number of Engineer Field Companies allotted to a division in our army is comparatively small, and it is certain that in field operations they will require economical handling on sound lines if their full tactical value is to be obtained. One often hears it stated that three instead of two companies to a division would be a more suitable establishment, and as an additional reason for this it is held that each infantry brigade should have a field company, if not as integral portion of itself, at any rate at its disposal whenever it is actively employed. This reason is not a sound one. Though an additional company is highly desirable, any normal distribution of field companies to infantry brigades should be guarded against. It overlooks a very large section of the troops of the division which may require help from the engineers, viz. the artillery, and it further assumes that the requirements of the infantry brigades will be equal and symmetrical, which would probably never occur in practice. The engineers must be divisional troops, and remain in the hands of the divisional commander to allot as he thinks best to meet any emergency that may occur.

When the division is advancing, it is customary to allot one or more sections of engineers to the advanced guard, and of these a portion will join the vanguard and will send forward cyclist scouts as far to the front as possible. The action of an advanced guard on encountering the enemy is well known. It will act with vigour, endeavouring to push aside his covering troops and to gain touch with his main body. When it can get no further it will dig itself in, with the intention of forming a covering screen behind which the deployment of the main body may be carried on without molestation.

The engineers with the vanguard will be involved in the initial fighting. Their *raison d'être* is not so much an offensive one, as to facilitate the march of the troops; and in the case of a collision with the enemy they should be utilized in clearing the way, and possibly also in the defence of some strong point, some enclosure or group of buildings which may be found on the spot, and which might form a pivot for the attack in case unexpectedly resolute resistance is met with. This action may have to be repeated two or three times before the advanced guard is really held up by superior forces. The end will probably be that the vanguard engineers will be expended, as far as their tactical value is concerned, in the thick of the advanced guard firing line.

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The rest of the advanced guard engineers will arrive on the scene near the head of the main guard, and if they are not required to improve communications for the artillery either at first or as the action develops, they should be kept in hand until the time has come for the advanced guard to dig themselves in, when they should be sent forward to the more important point or points of the line. There should be no attempt to distribute them widely along the front, but the commander should endeavour with their help to build up one or more pivots in his line, on which to base his defence during the overwhelming counter-attacks, which he has reason to expect from an enterprising enemy, before the main body can arrive to his assistance. This we may consider to be the end of these sections for the time being. Pinned to the ground and engaged in a desperate defence, they would be no more available until the success of the main body has extricated them, or until the darkness of night enables them to be withdrawn, though, on the other hand, if the advanced guard position becomes part of the firing line of a many days' battle, the darkness of night may mean only an opportunity for improving their defence works. All things considered it would not be wise to count upon the use of their services again during this particular operation.

Turning now to the action of the main body, we find the rest of the division left with little or no more than a single field company of engineers to carry out all the duties which may be required of these troops during a battle. That these duties are by no means simple or few in number may be gathered from a study of Section III of *Engineer Training*, and when it is further laid down that "no considerable portion of the division ordered to carry out a distinct tactical operation should be without its complement of engineers" it will be recognized that their resources, even if they have not already detached a section with the rear guard, will be strained to the uttermost.

Early in the action serious bridging or ferrying problems may have to be tackled, and in this work it is possible that the bridging equipment of the field companies may be called into requisition. If this can be foreseen the pontoons should be brought up in good time to join their companies at the head of the column, for otherwise they will be with the brigade ammunition columns and it will be difficult to get at them quickly.

In detailing engineers to tasks in distant parts of the field, it will be remembered that most of them are dismounted troops and can move no faster than infantry. It should, however, be noted that they have eight cyclists per section, and that a few men can always be carried rapidly on the tool carts in case of necessity.

The need of observatories and crow's nests will probably become prominent at an early stage, in view of the care with which positions are selected to conceal the effect upon them of artillery fire.

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Officers preparing for possible future moves of the artillery may require help in cutting openings through natural obstacles, especially when the necessity of the concealment of such moves becomes an all-important item.

The advance of the infantry to the attack will not under the ordinary circumstances of field warfare require any help from the engineers, nor will this be expected. If the country is very close, or even if there are known to be hastily constructed artificial obstacles in their path, there would be nothing easier than to equip a small portion of the infantry with hand axes or cutting pliers. Engineers would be wasted if distributed upon such duties, especially as there is always a far more important service in which their concentrated skill may be of the utmost value, the preparation against counter-attack of some important key which has been gained during the attack. This important service is laid down in *Field Service Regulations* as the work of the local reserves, to which engineer field companies may be attached for their assistance. Here we get a ruling as to the detailing of engineers with other troops in an attack. A special objective is assigned to the operation, special troops are detailed for the attack, and a local reserve is told off with the special object of following the attack and making good against the enemy the defences of the objective when it has been gained. The engineers are attached to this reserve and are placed under the orders of its commander. The attack may follow up its success, knowing that it can count upon the solid backing which will be found, if it is driven back, in the hasty defence work of the local reserve and of its engineer contingent. There is reason to believe that this procedure is not often practised during peace operations. Engineers alone, in such a case, could show but small results, but engineers with infantry *if well trained in utilizing to the utmost their combined efforts*, might in the shortest space of time do work whose effect upon the result of the operation might be little less than decisive. We may assume that there will always be a counter-attack, there will always be an attempt to regain a lost point of vantage if it is of any value, and if this counter-attack is made by fresh troops, more often than not the crucial struggle will take place round the defences hastily organized by the commander of the local reserve with the help of his sappers in the key of the captured locality.

The paragraphs in *Field Service Regulations*, Part I., devoted to night advances and night assaults, bring out prominently and in considerable detail an important application of this action. Here we see the detail of the assaulting columns and of the reserve ; here the equipping of the working parties as a result of engineer reconnaissance of the objective ; here the provision of hours of darkness to enable them to prepare and organize their defences against a counter-attack at dawn. There is no doubt that all available sappers must be concentrated to work with this reserve, and if any have been

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employed earlier in the night in assisting the stage management of the night advance, but few can be spared for such rudimentary, though honourable duties as wire cutting and such like at the head of the assaulting columns.

In siege warfare the conditions are different. Here the obstacles are more formidable, and the task of driving avenues of approach into the heart of the enemy's works requires highly technical skill and training. In this the engineers will take a prominent part, and the divisional companies will be largely reinforced " by units specially trained in the work of sapping and mining."

In a *retreat* the duties of engineers are multiplied. The rear guard must have its contingent to assist in making demolitions and obstructions in its rear. Incidentally it may be suggested that supplies of explosives for their use may be left with the food and ammunition on the roadside to be picked up *en route*. The head of a retreating column cannot safely be left without an engineer party to remove incidental obstructions in its path. There is also important work for engineers in the preparation of rallying positions. Here it is possible that help may be required by the artillery, both to give access to positions from which the best tactical results can be obtained, and also in view of retirement to save them from becoming entangled in a difficult country.

In *defence* the uses of engineers are well known in the preparation of a defensive position, but it should be borne in mind that it is better to concentrate the sappers in the more important pivots than to scatter small parties in an attempt to give engineer assistance to every pivot. The question arises :—Should the engineers be left indefinitely to share in the defence of the pivots to which they are allotted ? It is true that the defence work on a pivot can hardly ever be said to be completed. The very conditions of defence of these strong points require that no efforts should be spared to render them impregnable ; and yet one would not wish to see the few engineers who are included in the establishment of the army allowed to be involved in the defence, and thereby lost to the more important work of the counter-attack.

This same question may occur in all defence work in the occupation of *points d'appui*. In the case of an advanced guard it cannot be helped. They dig themselves in in the face of the enemy, it is fighting from the first and all the force will necessarily become inextricably involved. In other cases they should be withdrawn, and the decision as to when they should be withdrawn must depend upon circumstances. They will seldom be able to put the finishing touches to their work, but none the less it is conceivable that they will upon occasions become involved in serious fighting.

Their normal place is with the local reserve of the attack. They are not in sufficient numbers to be everywhere and they are essentially troops belonging to the attack and should not be expended in local defence.

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DELHI DURBAR, 1911.

(Continued from January).

REPORT ON THE SURVEY AND DEMARCATION, AND THE FIRE PRECAUTION ARRANGEMENTS.

By LIEUT. P. C. HOBART, R.E.

AT the beginning of February, 1911, I reached Delhi with a section of 1st K.G.O. Sappers and Miners to undertake the correction of the existing map. The map in question was on a 4-in. = 1 mile scale, made about 40 years ago. It proved to be so inaccurate—the river Jumna having changed its course as much as two miles, and the alignment of canals, roads and railway having apparently altered—that I found it necessary to re-survey the whole area afresh. An area of about 40 square miles was comprised, and urgency was of the first importance as the whole of the work of allocation of sites, roads, railways, water and light, was greatly hindered until the map could be distributed.

I found it advisable to work from a carefully chained base, in order to avoid the delay necessary for the production of a properly graticuled-board. The sketch was frequently checked by long chainages on a ray, which latter were also useful as the basis for the large 16-in. plans of the various camps which were afterward produced. The abnormal rain of the early part of the year added considerably to the difficulties.

In the second half of February, the work of demarcation of camps commenced concurrently with 16-in. survey by Sappers of the 1st S. & M. The camps laid out were for some 90,000 fighting men in addition to all auxiliary services and about 400 camps of civil authorities, Indian chiefs, etc. Ground was very limited owing to various considerations. Distance from centres, liability to flooding, communications, water supply, compensation for crops, etc., etc. And there was difficulty in fitting the camps to the available ground, without undue dispersion or concentrations and with strict regard to the Divisional Organization for war, their distribution in armies for manœuvres, their routes across the Jumna to Durbar camps after manœuvres, and precedence on parade.

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Various changes in plans of sanitation necessitated one entire rearrangement of all the military camps, and the various alterations and amplifications of the original order of battle involved constant adjustments later. But by the end of April the demarcation was practically completed. Corners of camps were marked by permanent brick pillars in lime, and the entrance and exit of every road, by tarred pillars. Each was exactly sited by theodolite. About 350 pillars were built and 600 posts erected. In the military camps, and in most of the civil areas, bounds were fixed to the posts bearing abbreviated designation of the unit, and its division and brigade. Altogether about 30 different plans were produced, including one in the vernacular and two for the State Garden Party programme. About 20,000 maps were distributed. 10,000 copies of the final issues of the 4 in. and 2 in. to a mile general plans were admirably reproduced in five colours by the Supdt. of Government Printing, Calcutta, and were of the greatest use: they were included in the Official Directory, and in the military scheme. Five battalions of pioneers and two of infantry were employed under the military staff on works previous to the Durbar. Their work consisted of levelling and clearing completely about 4 square miles of tent sites, 30 miles of Kutcha roads, culverts, causeways, watering ghats for animals and 1½ miles of canal cut, and the preparation of a parade ground 2 miles in area (involving turfing a large portion) from an area originally consisting largely of hills and saturated with saltpetre. In August, 1912, I was appointed Staff Captain on the Durbar Military Staff. The distribution and supervision of military labour were part of my duties. All the road signposts with map-boards, five nullah bridges and three railways overbridges were put up by 1st K.G.O. Sappers and Miners.

The design and provision of a uniform pattern of name board for all civil and Indian chiefs' camps was found necessary late in the day, and a month before the Durbar the Military Staff were asked to undertake the decoration of Kingsway (¾ mile) and Prince Road (1½ miles). The carrying out of both works was made over to me.

A boxing area to hold 7,000 spectators was built under my superintendence. About Rs.10,000 profit was cleared on the tournament, which was devoted to initiating a Boxing Association in India.

A copy of the report on fire precautionary arrangements submitted to the Durbar Committee, is attached. The look-out towers were built of telegraph poles by 1st K.G.O. Sappers and Miners and were quite satisfactory.

The majority of my work was of an ordinary staff nature, having no special bearing on engineering matters, and is not therefore touched on in these reports.

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Fire Precaution Arrangements.

The fire protection measures were of two kinds :—

1. *External.*—Under the direct orders of the officer in charge of the fire precautions. The main object of these measures being to provide well-trained, organized, and equipped squads at convenient points, always in a state of instant readiness to prevent the spread of a fire and to assist local brigades. 50-ft. towers were provided for a sentry at each picket. Signals were arranged for night and day, and a private telephone system connected each picket with the tents of the fire officer and his assistant, where one of the two was constantly on duty night and day. It was the duty of the pickets to proceed at once to any outbreak in their area, as soon as perceived—not to wait to be called.

2. *Internal.*—Circulation of notes, memoranda and instructions on all matters into which any possible risk of fire appeared to enter. The rapidity of tent fires, and the necessity for the provision of a suitable fire brigade in each camp to cut down a burning tent at once, was impressed on camp officers together with the fact that they were responsible for the preventive measures and for actual extinction of any outbreak—the duty of the main fire pickets being to prevent the conflagration spreading. Previous to the Durbar period, the fire officer went round each camp in the central area south of the Mall, with the camp officer, and made suggestions and gave any help in his power. Officers were invited to send their local brigades to attend the practices of the fire pickets, which were carried out daily. Lectures were given at meetings of camp officers of Indian chiefs' camps.

Fire Engines.—In view of the special nature of tent fires and the comparative uselessness of fire-engines, only three were provided :—(1), In the camp of His Imperial Majesty the King-Emperor; (2), centrally in charge of No. 5 Picket, Kingsway; (3), at the amphitheatre. These were always kept under steam and were in direct telephonic communication with the fire officer.

Arrangements were also made in each area that a certain number of private engines belonging to camps should be available for use when required.

Incendiarism.—To guard against incendiarism, etc., at such important buildings as the amphitheatre, ridge pavilion, etc., special police guards were arranged and a large number of patent extinguishers were provided. At the Durbar amphitheatre, also, was stationed a fully-equipped and trained fire brigade, kindly lent by the Jubbulpore municipality.

Details of Outbreaks which Occurred.—Previous to the Durbar period there had been three fires in camps, and two considerable petrol fires, one at the central garage and another at Delhi Railway Station.

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Beyond the loss of the petrol and the shed wherein it was stored, no further damage was done in either fire. The special precautions taken for storage of petrol were effective, and no further fires were due to this cause.

Between December 1st—18th there were seven outbreaks. Of these the most important were that in the camp of Lieut.-Governor of the Punjab, and that in His Imperial Majesty's camp. The former broke out in the main block of reception tents, etc., about 4.45 p.m. on Sunday, 3rd December, 1911. The local fire brigades of the camp and those adjoining were promptly at work, and four fire pickets arrived shortly after. It was impossible to save the main block in which tents and shamianas were firmly lashed together and supported in places by steel uprights let into solid masonry. A good deal of valuable property was saved, and by the prompt striking of neighbouring dwelling tents the fire was prevented from spreading. Some confusion was caused by excess of amateur assistance, large crowds of coolies from the King's camp, and police not in uniform rendering organization difficult. Steps were taken after this to enforce more strictly the orders issued to the police. The cause of this fire is uncertain. It seems probably to have been due to tampering with electric fittings when fixing a bell; but it is possible that it may have been caused by a cigarette end.

H.I.M. the King-Emperor's Camp.—The fire in His Imperial Majesty's camp occurred about 11 p.m. on 14th December, 1911, in the fourth tent from Her Imperial Majesty the Queen's apartments. The investiture ceremony was in progress at the time and 3,000 people, chiefly high officials, chiefs and officers of high rank were assembled thereat in the big reception tent. To know that a fire was in progress close at hand, without knowing its exact location, caused considerable anxiety, but all the arrangements worked excellently, and the burning tent and the four adjoining it were on the ground within two minutes of the first alarm. The Flagstaff fire picket was on the scene within 1½ minutes of the outbreak. The fire was completely extinguished within five minutes; no damage being done to any thing except the actual tent where it originated and its contents. The cause of the fire is not thoroughly substantiated. It may have been due to a bicycle with lighted lamp being leant against the tent wall, or to an oil stove which was found to have been burning in the tent.

In addition to the above, other fires that occurred during the period December 1st—18th are shown below. These were attended by one of the fire pickets:—

Date.	*Time.*	*Site.*	*Damage.*
6. 12. 11.	2.10 a.m.	Wazir of Hyderabad.	1 tent.
6. 12. 11.	6.45 p.m.	Site 401.	1 motor car.
12. 12. 11.	1 a.m.	Press camp.	1 tent.

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There were also small fires in Camp No. 15 on the 2nd of December, 1911, and in Camp 4.

I have the following suggestions to offer for improvements on a future occasion :—

(1). The executive staff to be increased. With one assistant, only, it was not possible even to inspect properly the camps for which the fire officer was responsible ; and it is quite impossible to ensure that recommendations have been carried out. This staff should be struck off all other duties and provided with motor conveyance. A large amount of ground has to be covered, and in cases of emergency it is essential that the fire officer should arrive as quickly as possible.

(2). The police should be carefully trained in their duties, as originally agreed upon. How imperfectly these were understood was well shown at both the Punjab fire and that in Camp No. 1, when a large crowd of all kinds of people assembled from all sides, greatly retarding the work of the fire pickets and rendering very difficult the detection of looting. The police, instead of forming a cordon and keeping the camp clear of all unauthorized persons, were engaged in misdirected and ineffectual efforts to deal with the fire, for which purpose a satisfactory organization already existed. This omission might have led to considerable loss of property.

The following memorandum on fire precautions was issued and is attached for information.

"1. The Committee will, with effect from the 1st of December, 1911, establish five fire observation stations in the camp area, viz. :—

(*a*). The Flagstaff Tower on the ridge.
(*b*). The band stand.
(*c*). The Kingsway Railway Station.
(*d*). Dahirpur.
(*e*). The rifle butts.

At each of these places a picket consisting of one officer and fifty men will be permanently stationed ; telephonic communication will be established between the various pickets, and the nearest picket will proceed immediately to any place in which an outbreak of fire may be detected. Arrangements will also be made for the immediate despatch of a body of police, assisted if necessary by a detachment from the military camps, in order to form a cordon where this is required and to preserve order in the neighbourhood of the fire.

2. It will be incumbent on camp officers to adopt the necessary precautions to prevent an outbreak of fire in the areas under their

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charge. The principal precautions which should be adopted are as follows :—

(*a*). The use of naked lights or any form of oil lamp or candle, except hurricane lamps, should be absolutely forbidden except in those camps in which the Committee have admitted the use of other means of internal illumination than the electric light.

(*b*). Fires for cooking, etc., should be lit only in authorized places, and sand bags and receptacles filled with earth should be kept adjacent to servants' tents and quarters.

(*c*). It should be impressed upon residents in the camps that the utmost care must be taken in the disposal of cigarette ends, matches, etc., and camp officers should forbid the smoking of hukkas in unauthorized places.

(*d*). As fire may be caused by the fuzing of electric wires, if any fuzing is detected, the current should at once be switched off and if the fire still continues it should be extinguished by hand-grenades or similar means.

(*e*). Stacks of hay should not be placed nearer than 50 ft. to any tent, and it is advisable, where possible, to place them in the proximity of irrigation channels. It is recommended that an arrangement should be made by means of chains or wires so that each layer can be rapidly pulled down to the ground and the extinction of fire thus facilitated.

(*f*). Separate instructions are issued as to the storage of petrol (see paras. 8—11) below.

3. It is advisable that each camp should be provided with some form of patent extinguisher in order to put out at once any small local outbreak of fire inside the tents.

The Minimax Fire Extinguisher has already been brought to the notice of the camp officers. Where camps possess pumps and hose it is advisable that tanks should be provided sufficient to allow the pump to throw a supply of water on the tents which may catch fire. A number of sand bags or other receptacles filled with earth should be kept in readiness and a supply of fire buckets should be kept always filled with water.

4. A small fire brigade should be organized in every camp and provided with billhooks, kukris or knives for quickly cutting down a burning tent. Their duties should be carefully explained to them and rehearsed at intervals. Should a pump be kept in the camp they should be trained in its use and they should also be instructed in the use of any patent extinguisher adopted in the camp and in the method of making a chain for passing buckets.

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5. Instructions should be drawn up and published in camp directions or otherwise for the procedure of all inmates of the camp in the case of fire. It is advisable for the native followers to rehearse the action which should be taken by them in the event of an outbreak. Special precautions should be taken against thieving and looting of valuables in tents when a fire takes place.

6. On the outbreak of a fire the action to be taken by the fire party should be, with due regard to the safety of its inmates, to cut down the tent in which the outbreak occurs and such neighbouring tents as appear likely to be in danger. It should be impressed on the fire party that the best and frequently the only way of subduing a fire in camp is to cut down the tents; when tents have been levelled to the ground, pumps, if they exist or buckets, may be brought into play or earth thrown on the fire.

7. As soon as fire is detected, immediate information should be sent either by telephone or mounted messenger to the nearest fire picket, and the police camps should also be advised by telephone or messenger.

Special Rules regarding Petrol.

8. A central depôt for the sale of petrol will be established in the camp area by a well-known firm which will make daily deliveries at the different camps. There is therefore no necessity to store a large quantity in any camp, and a maximum of 4 gallons for each car exclusive of the amount in the tanks of the car has been fixed.

9. The rules issued by the Punjab Government under Section 9 of the Indian Petroleum Act, 1899, Notification No. 90, dated the 15th of February, 1909, require owners or hirers of motors who store petrol to take out a license for this purpose. No fee is charged for the license. Particular attention is invited to the fact that a shed must not contain more than 60 gallons. The drum should, in the opinion of the Committee be sunk in the ground, but the sheds can be of the simplest description.

10. In addition to the condition laid down in the license the Committee consider that (1) no shed should be nearer than 30 ft. to any tent, and (2) that a supply of earth and shovels should invariably be kept handy for filling the pit on emergency.

11. The only petrol to be kept in the camp garage should be that in the tanks of the motors; the remainder must be kept in the petrol pit.

12. Camp officers should intimate to the Committee at their earliest convenience the amount of petrol which they desire to store in their camps calculated on the basis of 4 gallons to each motor. The Committee will then arrange to apply for the necessary licenses."

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REPORT ON WORKS CARRIED OUT BY MILITARY WORKS SERVICES.

The first work handed over to the Military Works Services was the construction of roads on military camps. A staff of one officer and one upper subordinate arrived in Meerut on May 11th, where it was found that an estimate providing for 12 miles of metalled road had been provisionally sanctioned. Of these roads about 3 miles were to be metalled 16 ft. wide and the remainder 10 ft. wide, the metalling to consist in both cases of 6 in. of metal without soling.

On proceeding to Delhi, it was found that :—

(*a*). About 10 miles of the proposed roads were on such low-lying ground that no work would be possible during a normal monsoon.

(*b*). The only source of stone for road metal was the ridge.

From this it was clear that the collection of metal was a very urgent matter, firstly because only two months were available to collect some 300,000 cubic ft. and secondly because this metal when collected would have to be carted for distances up to 7 miles, much of which was across country.

After some days had been wasted in calling for tenders and endeavouring to get stone collected and carted by local contractors, who held out for very high rates for both items, it was found necessary to employ outside contractors who would import labour from other districts. By May 25th three outside contractors had commenced work, and as time went on increased their gangs and output of road metal. One local contractor was also at work, but his progress was so unsatisfactory that his orders were cancelled. By 20th July, practically the whole of the metal had been collected and carted to the road alignments, and as the rains were overdue, work was more or less suspended for some time. Later, as the monsoon had partially failed and the concentration of the troops was as a result reduced, orders were received reducing the total length of the road to be constructed from 12 to 9 miles. In September, as the rains seemed to have failed, work of consolidation of the higher-lying parts of the road was commenced. Owing to the heat and dryness of the air consolidation was very difficult, but as roads were likely to be required for early preliminary work other lower-lying roads were taken in hand during the month. Towards the end of the month a very unusually heavy fall of rain entirely stopped work, some parts of the lower road being under 2 to 3 ft. of water. Work was resumed early in October, but even then the sodden state of soil rendered consolidation difficult and in some places impossible for

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some time. Finally all roads were satisfactorily consolidated by November the 15th, just before the arrival of the advanced parties of the troops to be concentrated for the Durbar.

In connection with roads construction several points were noted.

(*a*). Pathans and men from Hazara District who were accustomed to stone breaking and quarrying turned out much more work per day than local coolies. In spite of the higher wages paid to Pathans, there is no doubt that the employment of these men facilitated work.

(*b*). It was found necessary to cart chippings from the quarries to the roads to form a " binding." Roads could not be satisfactorily consolidated without this.

(*c*). Trained men were necessary for the satisfactory consolidation of stone roads, especially when, as in this case, the soil is unfavourable. A small number of trained mates is all that is really necessary, though it was found that Pathan coolies being of superior physique were most useful on the hard work of spreading metal.

Minor Works.

Towards the end of July a number of minor works in or near Delhi Fort were proposed, and others continued to be sanctioned until November. None of these works were of any particular interest being merely alterations and additions to existing roads and buildings. The value of the work done eventually amounted to about Rs.22,000, and was carried out by the ordinary M.W.S. Staff of the Delhi Subdivision.

Furniture Supply.

Large quantities of furniture were sent in from various stations for the use of troops and others concentrated at Delhi. For this work an extra staff of three barrack sergeants was sent, and three depôts were established for the issue of furniture. As furniture was drawn and returned to the depôts by the regiments or others concerned, no difficulty was experienced in distribution. Considerable difficulty, however, arose in connection with the cartage of furniture from railway stations to depôt, owing to large consignments arriving simultaneously and transport not being available. This was mainly due to the disorganization of the railway traffic after the floods of September, which upset arrangements and delayed delivery. The furniture supply appears to have been quite satisfactory, and to have added greatly to the comfort of the troops. The only addition which might be suggested is " chopping blocks," the want of which was sometimes inconvenient.

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WASHING PLACES FOR BRITISH TROOPS.

Temporary washing places were provided for British troops, both for men and for washing kitchen utensils. The washing places for men consisted of grated tables supported by trestle legs, a drain of match boarding being fixed along the legs to catch the water falling through the grating. The water collected by this drain fell into an open channel cut in the ground which led into an absorption pit. These tables were surrounded by a screen of matting supported on rough wood uprights, and were provided with gratings on which men could stand while washing. The only difficulty experienced in connection with the work was due to the fact that the whole of the tables, etc., had to be erected between the time of arrival of the advance parties and the time of the arrival of the main body. This difficulty was surmounted by cutting up and collecting all the material at a central depôt. The erection was then handed over to Lieut. B. T. Wilson, R.E., who had been especially sent to Delhi to assist in this work, and who succeeded in erecting the whole of the very large number required some two days in advance of time.

The washing places for cooking utensils were of exactly the same design as those for men, with the exception that they were not provided with screens. Both kinds of washing places seem to have been appreciated, and to have added greatly to the comfort of the troops. In some cases the absorption pits did not act satisfactorily owing to the nearness of the subsoil water which rendered absorption very slow. This difficulty was to a certain extent surmounted by increasing the size of the absorption pits, but it was evident that in cases of this sort where the subsoil water is very near the ground level, absorption pits cannot deal satisfactorily with the large amount of water used in lavatories of this sort.

A statement showing the various services connected with the Durbar Works, together with their approximate cost, carried out by the M.W.S. and adjusted by debit to the Military and Civil Departments respectively, is enclosed. Roughly the figures of expenditure stand as follows :—

(i.). Works adjusted through the Central Adjusting Account	Rs.138447/-
(ii.). Works adjusted through the Civil Exchange Account	Rs.18091/-
(iii.). Works done out of the Military Works Funds	Rs.7043/-
Total ..	Rs.1,63,581/-

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WORK DONE BY H.M. MINT, CALCUTTA.

His Majesty's Mint, Calcutta, was responsible for the manufacture of the gilt solid silver thrones used by Their Majesties at the Durbar. These thrones are of Georgian design and are facsimiles of two in the possession of the Government of India which were designed and made in 1875 by Messrs. Hamilton & Co. The originals, which are of wood covered with thin sheet silver, were handed over to the makers for renovation and new upholstery.

For this work they had to be taken to pieces, and advantage was taken of this by the Mint to mould each piece separately, casting them with suitable lugs to allow of the various parts being assembled later. But little difficulty was found with most parts in castings solid and well-detailed work but the lions forming the arms of the King's chair, each of which weighed 1 cwt., and a few other pieces which had elaborate detail in several faces required special treatment. They had to be cast in moulds prepared of specially fine sand, and it may be interesting to note that the silt from the bottom of cisterns supplied by the municipal unfiltered water supply was found eminently suitable.

The rough castings were chased and finished by Indian engravers, 11 men working under the general superintendence of Mr. F. K. Wezel, engraver to the Mint, and no difficulty was found in this part of the work. When the gilding, which was done electrically, was first put in hand, it was found difficult to get the gold deposit of one colour on all the different parts. A short series of experiments revealed the secret, and absolute uniformity was obtained.

The various parts of the chairs and footstools were dovetailed together and pinned where necessary.

The upholstery was supplied by Messrs. Hamilton & Co., two identical sets of cushions being made, one for the Mint thrones and one for the renovated chairs.

Owing to the weight of the thrones and the necessity of protecting the delicate work and the gilding, it was deemed advisable that they should be erected at Delhi by one of the Engineers responsible for their manufacture. A slight mistake in fitting such pieces of comparatively soft metal together might have resulted disastrously.

Rs.96,000 of old rupees were melted to produce the silver, and the completed thrones with their footstools weighed 1,911 lbs. The cost of the work excluding the upholstery was Rs.3,000.

Two hundred gold and twenty-seven thousand silver Coronation medals were also made in the Mint. The obverse is an enlarged copy of that of the home Coronation medal. The enlargement from the small die sent out from home was found difficult, but the difficulty

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was surmounted by cutting a replica of about three diameters in soft silver so that the cutting tool was not unduly worn. The face of this soft silver replica was then nickelled to make it sufficiently hard to stand the wear of the pointer, and from it was cut the die of the required size for the Indian medal. The medal fittings and the brooches for the ribbon attachments were also manufactured in the Mint.

From the date of receipt of the die from England till the completion of the first order of 200 gold and 25,000 silver medals, only 16 weeks elapsed, a very creditably short time when it is remembered that the Mint was busy not only with the thrones and the tournament medals and official passes for Delhi, but also with the preparations for the new coinage.

The whole work was carried out under the immediate direction of Capt. G. H. Willis, R.E., and in recognition the decoration of M.V.O. (4th class) was conferred on him at the Delhi Durbar in December, 1911.

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THE WORK OF THE ENGINEERING STANDARDS COMMITTEE.

By CAPT. A. E. DAVIDSON, R.E.

SOME of the greatest movements of the engineering world have started from small beginnings, and among these can be included the work of The Engineering Standards Committee. Before this Committee started there had been individual attempts to make standards in various branches of engineering—such as the Whitworth screw thread, but there was no organization to help on such individual efforts and give them publicity. Standardization is no new thing; it has long been recognized as being absolutely necessary in civilized countries in our daily intercourse. Money, weights, measures, distance, time, all these have had their standards fixed in each individual State as a necessary basis for the dealings of a community.

More detailed standards are also agreed upon, such as the width of track of railway lines, the bore of rifles in the different armies, etc. There is no need to argue the necessity for their adoption, it is self-evident. Imagine the confusion and waste of time if each railway company in Great Britain adopted a gauge of its own! Imagine the difficulties of the ammunition supply of an army in which each regiment was allowed to choose the size of bullet that should be used in its rifles!

These are obvious cases, but they demonstrate the value of standardization in detail, and it now remains to show that the same principles can be, and should be, extended to wider ranges than formerly. When the subject comes to be looked into, there are far more standards already in existence than is perhaps realized. In addition to those mentioned above—money, weights, measures, distance, time—there are examples such as sizes for clothes, sizes for paper and books, sizes of photographs, and many more that need no mentioning.

Some of the above are international standards such as time, latitude and longitude, others are only national, such as weights and measures, and vary from country to country. Where they differ they are a source of confusion. Take for instance the ton. In America it is 2,000 lbs., in metric measure the ton = 1,000 kilogramme = 2,204 lbs., while the British ton = 2,240 lbs. This is typical of the small and not really important variations that occur in general engineering work, unless some body which has the confidence of engineers

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takes the matter in hand and lays down standards that can be accepted by all and freely referred to without any doubt as to their features.

Now what is the need for standardization? From the purely commercial side of our great manufacturing industries its value cannot well be overestimated. It is the essence of low production costs, and this is in its turn the essence of plentiful supplies of manufactured goods at moderate prices. It is one of the strongest weapons that our manufacturers have of fighting foreign competition. In cases where foreign goods have been sold in large quantities in this country, it has been due to a large measure of standardization having been adopted in their manufacture, and has in many cases been met by an answering measure of standardization among manufacturers at home.

Several British manufacturers have objected to standardization of parts of their productions. This was particularly noticeable in the early days of the motor-car industry, where makers thought that if they could only make the parts of their vehicles non-standard and different to those made by others, purchasers would be bound to come to them for replacements which would be sold at a higher profit than the original vehicle. It was quite overlooked that this cut both ways as no owner of another make of car could come to them for replacements, and those who had purchased vehicles from them not getting value for money soon kicked against being forced to pay a high price for articles which could not be bought in competition.

The French on the other hand perceived the value of specialization and standardization at an early date in this industry, and by getting some firms to specialize in the manufacture of details for a large group of car builders, they were able to produce their vehicles comparatively cheaply.

It was also maintained by some that standardization would mean stagnation and would be a hindrance to young and growing industries or branches of engineering. While it may be true that standardization injudiciously carried out is a drawback, in that it tends to check invention, improvement, and research, it must be admitted on the other hand that certain details can very well be settled on without hampering new design, and, by being fixed, will actually help invention because they free the inventor from having to waste time on unnecessary detail.

In order to meet this objection, the standards fixed by the E.S.C. in this country are periodically reviewed—as will be seen later—with the idea of embodying in them any changes which progress in science or engineering render advisable.

An example of the drawbacks of not standardizing was recently provided when identical engines were being supplied by firms to two

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Government departments; to one with British Fine Screw threads; to the other with that department's own special thread. The price to both was naturally higher than it need have been, and the engines and their spare parts were not truly interchangeable. The advantages of standardizing were so obvious in this case that the special departmental screw thread has now been withdrawn.

What is the value of standardization from an R.E. officer's point of view? It will save his time, and ensure that his work can be carried out in a rapid and economical manner. Standardization is a saving of time because it makes the designing of many minor details absolutely unnecessary. For instance, who wants to waste time in designing a screw thread either as regards the form it should take, or the number of threads per inch that should be employed? These details have all been worked out with the greatest care as the result of very wide practical experience and are embodied in tables. All that has to be done in making a design is to choose the standard size or type that best fits in with requirements. Again why waste time in designing, *ab initio*, the scantlings and form of a steel section in a bridge or a floor? This has all been done: it is only a question of choosing the most suitable section from a set of tables. Rapid and economical execution of work is ensured in both the above instances if standard forms are selected. Rapid, because the sizes and types selected will probably be available from stock—or, if not, will be more easily secured. Economical, because the parts can be taken from stock, or can be made from dies or rolls that are in common use, and in neither case does special machinery have to be manufactured before supplies can be made. Sir J. Wolfe Barry has quoted the following example as showing how money is wasted by the use of non-standard sections for a steel structure:—

"For a steel structure some 200 tons of a certain odd section were insisted on by the architect instead of allowing an equivalent standard section. This, of course, entailed the cutting of new rolls, with a consequent cost of £200, and, apart from delay, the architect's clients had to pay £1 per ton more for their non-standard section than they would have done if the contractor had been allowed to use a standard section of equal strength."

The examples cited above may appear to be almost too obvious to mention. It is because they are so obvious that they are of value, for they illustrate the more clearly the value of standardizing. Once this fact is admitted it is easy to extend the subjects in which standards should be fixed.

The Committee whose work is now being dealt with was formed in 1901, as the outcome of a resolution moved by Sir John Wolfe Barry to the effect that the Institution of Civil Engineers should take action to establish a Committee to standardize forms for iron and steel sections. That Committee was formed, and now after

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13 years, under the name of the Engineering Standards Committee, it consists of 19 sectional committees divided into a great many more sub-committees. It has the support of the leading Engineering Societies in the country.

When only dealing with its original reference the Committee was supported by

The Institution of Civil Engineers.
The Institution of Mechanical Engineers.
The Institute of Naval Architects.
The Iron and Steel Institute.

Towards the end of the first year's work the original reference was enlarged to embrace the standardization of locomotives, and tests for engineering materials. Subsequently the standardization of electrical plant was undertaken, and the Institution of Electrical Engineers was added to the list of societies supporting the Committee. At the end of 1902 it was decided by resolution of the supporting institutions to confer upon the Committee " power to act with respect to publications . . . to give effect to the findings arrived at from time to time in respect of the questions referred to them."

The work done by the Committee has been enlarged very considerably since that time and embraces a very wide field of subjects. The subdivision of the work is shown in the form of a genealogical tree, which also illustrates the method by which the Committee acts.

Each sectional committee formed to deal with a subject, such for instance as electrical work, is free to form sub-committees for various phases of the work in hand. These sub-committees report to the sectional committee, and no publications are issued before the results have been before the main Committee. This prevents the sub-committees from working in watertight compartments and issuing findings or specifications at variance with those issued by other committees. The work of many sub-committees overlaps that of others. For instance, key ways and screw threads are dealt with by both the Screw Threads and Automobile Parts Sectional Committees. Some of the members of one Committee belong to the other, and are therefore enabled to co-ordinate the work that is being done under the two separate heads.

Some of the work shown in the Tree has already been completed, and reports have been issued. It has, however, always been recognized that all the committees are really standing committees, and that they may have to revise their work periodically and bring it up to date to deal with modern conditions as they arise. To meet this the Main Committee has ruled that each sectional committee should be afforded an opportunity of meeting at least once a year to consider whether any revisions in the specifications and reports drafted by it are necessary or desirable. As an instance of how this

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ruling would act so as not to fetter designs for new conditions, it may be stated that in the aeronautical industry where saving of weight is of the highest importance, bolts and nuts may have to be asked for in sizes intermediate between those already on the list. If this were considered necessary by the Aeronautical Industry the fact could be pointed out at any time when the report in question came up for revision.

The sectional committees are composed of representatives of Government Departments, Consulting Engineers, Contractors, Users, Manufacturers, and representatives of the Technical Societies. The object is to have as many views as possible represented on the committees, and special efforts have been made to ensure that manufacturers are represented, so that the findings of the committees can be taken up with the assurance that they are thoroughly practical and not merely theoretical.

The funds for carrying on the work of the Committee were at first supplied by the supporting institutions but later the Government departments were asked to support the Committee

(1) By giving grants ;
(2) By nominating representatives to the Committee ; and
(3) By the adoption of the Committee's standards when issued.

In 1903 the first Government grant was given, and since that time an annual grant has been given by the Home Government, while the Indian Government has given money as well.

The War Office, the Admiralty, and other Government Departments representing the Colonies as well as Great Britain, have representatives on all the sectional committees, and the Government Departments use the reports as far as possible in their specifications.

The Admiralty has largely supported the Committee's work by adopting the British Standard specification for steel in marine boilers, for structural steel in shipbuilding, for steel casting and steel forgings in marine work, and also for Portland cement in harbour work. The Board of Trade, Lloyds, Bureau Veritas, and other similar bodies have freely adopted the Committee's specifications in their rules and regulations.

Many public bodies, such as the L.C.C., in their general building regulations have required that all rolled steel used in the skeleton framework of buildings and all Portland cement shall comply with the British Standard specifications for these materials.

The tramway undertakings have shown that they appreciate the standards laid down by the E.S.C. for tram rails, as 68 per cent. of the tram rails rolled last year in this country were of standard sections, and in previous years this proportion has been even higher. A large amount of the remaining 32 per cent. will probably be found

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to be replacements of old sections instituted before the E.S.C. had issued recommendations, and possibly new types of section designed to meet special methods of connection, such as electric welding.

The Indian railway companies have ordered a large number of locomotives built to standard types.

As far as practicable, the whole of the material obtained by the Inspector of Iron Structures at the War Office is ordered from these specifications. The Mechanical Transport Committee also uses, and has used for some time past, some of the recognized specifications wherever definite qualities of material have been called for.

The need for further standards has been very badly felt in many cases. Take ball bearings, on which a sub-committee is working at present; it is now only possible to say that they must comply in size—no matter whose make they are—with the dimensions shown in Messrs. ——'s 1913 Catalogue. This is a very unsatisfactory method, and hardly fair to other makers whose names have not been mentioned. At least they say so, with some force, as soon as they see the wording of the clause; and the framer of the specification has to waste time in efforts at peacemaking instead of being able to refer to an E.S.C. report and have no further argument.

These instances indicate that the community at large appreciate the work of standardization, and show that the Committee's findings are backed up in practice and are received with confidence by engineers at large.

The international character of the work is not a feature that entered into the Committee's work at the outset, but it is now beginning to assume an important aspect.

In the electrical industry an International Commission was arranged some years ago, and work has been in progress with standing committees in various countries. One of the E.S.C. sub-committees has taken over this duty as far as Great Britain is concerned. The Commission is doing very valuable work, as it has already arranged international symbols for denoting current, pressure, etc., and has simplified and unified, as far as possible, the words used in the different languages to represent the same thing. And the work in connection with the rating of electrical machinery is in an advanced stage.

The sectional committee on pipe threads has just scored a great triumph for British Engineering in obtaining the international adoption of the British Standard pipe thread (gas thread).

The recently formed sectional committee on automobile parts is working with the American Society of Automobile Engineers, and both these bodies will consult each other in regard to any reports they may publish.

There is little doubt too but that the work of many of the committees will, in the not very distant future, be of an international

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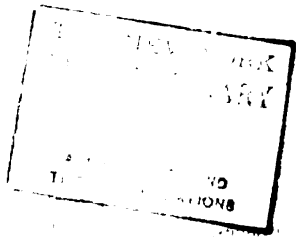

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lant. | Publication. | Screw a Limit

Rolled and awn Sections for use in Automatic Machines. | Small Screws and Screw Heads.

Water, Gas, and Sewerage. | Ho Ven. and Dr H

Telegraphs and Telephones. | Electric Tramway

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character. It is quite within the bounds of possibility, for instance, that international standards of screw threads in common use may be set up.

The work of the E.S.C. has not merely been confined to laying down standards from the best practice that has been available. Many of the final findings have only been arrived at after lengthy scientific and physical investigations, for which manufacturers have not the facilities. A large number of experiments have been carried out at the National Physical Laboratory. To mention a few of these researches only, to show how wide their field has been :—

Experiments to ascertain the effect of temperature on insulating materials used in electrical work. Other tests on insulating materials.

Experiments to ascertain the relation between temperature in different parts of field coils of electrical machinery.

Experiments to establish useful standards of life and efficiency in carbon filament glow lamps.

Experiments to show the degree of accuracy that could be worked to practically in factories dealing with various classes of engineering work.

Experiments to enable accurate screw thread gauges to be manufactured.

Experiments on the wear of road metals and bituminous materials.

Tests to show what is the best form of key and keyway for fastenings on shafts.

All the above have required original research before any really good and acceptable standards could be laid down, and have in some cases led to the designing and laying down of costly machinery.

A bare recital of the names of the sub-committees, or of the subjects they have standardized will not be of great interest, but a few remarks on some of the more important findings will call attention to the usefulness of the work.

A glance at the Tree facing page 87 will show how much of the material dealt with in ordinary building work or in I.R.E.M.'s work comes within the scope of E.S.C.'s findings.

Screw Threads.—Several types of thread have been standardized. All have the same form of thread, namely, that originally invented by Whitworth. Other countries have used, and are using other threads. The metric thread is used in France, Germany and other countries where the metric system is in vogue. The Sellars thread is used in the U.S.A. Experiments carried out at the National Physical Laboratory and elsewhere have proved the marked superiority of the Whitworth form of thread over all the others for resisting shock, and it is quite likely that the Whitworth will be

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adopted as an International Standard. The Germans indeed use Whitworth threads now for the really important parts of many of their engines and machines.

The original number of threads per inch adopted by Whitworth have been found to be unsuitable for much of the modern high-speed machinery, especially in the smaller sizes. Accordingly the E.S.C. has issued a fresh set of threads called British Standard Fine Threads. These only differ from the Whitworth in the number of threads per inch on a bolt of a given size. This is an example of how the Committee works to meet the growing needs of engineering, and encourages rather than retards invention.

For smaller sizes than these there are the British Association threads, which are employed in instruments and other fine work of that nature.

Then there are the British Standard pipe threads for gas pipes. This is practically the old "gas thread" and will, with but small modifications, become an International Standard. More recently further sets of threads have been fixed for several classes of hot-water and heating apparatus fittings. There are also threads for the metal conduits largely used in electric-lighting work.

This shows how the screw threads for practically every class of engineering work have been provided for by the Committee, and in making up any specification or drawing it is only necessary to mark on a bolt or thread say $\frac{1}{2}$-in. B.S.F., and all the other details can be obtained from tables.

Rolled Steel Sections.—These might be used for any bridge, girder, or roof work. If the structure were designed from the catalogue of any one maker and the sections were marked as being British Standard sections, one would be fairly certain of being able to obtain them no matter where the material was eventually procured. If they were not standard sections it might not be possible to obtain the exact sizes selected for the work, with a consequent loss of economy or loss of strength.

Automobile Work.—But little has been actually published in this section as the Committee has only recently been formed, but it will be a great convenience in the future to know that a motor car or motor bicycle has a few of the things mentioned below of standard sizes, so that in the event of replacements being necessary it would be fairly certain that parts to fit could readily be obtained locally or when touring.

Head and side lamps to fit standard brackets.

Tyres to really fit standard rims without damage and without blowing off the rim.

Ball bearings to fit without any difficulty.

Washers, small pins, sparking plugs, bolts, nuts and other small articles which frequently require to be replaced.

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Also that the name of a part on one make of engine did not differ from that given to an exactly similar part by another maker.

Road Material.—Work is being carried out on a road-testing machine to ascertain the best method of making up metalling into lasting roads. In this machine a circular road surface is actually made, and wheels with varying loads on them are run over it till it breaks up.

The specification for various sizes of road metalling has just been published, and special gauges have been made to enable its provisions to be properly checked.

Great diversity has been found to exist between the values of different bituminous materials for road making, and the report on this subject when published will be an interesting one, as indicating the unsuitability of some of the materials now used.

Materials for Engineering Work.—Practically all grades of metal commonly used in engineering work are dealt with in one or the other of the reports issued. In the one which deals with railway material for rolling stock there will be found the details of such materials as axle steel, material for many types and kinds of springs, material for ordinary mild steel as used in general structural work; steel forgings, steel castings, in addition to, copper plates, copper rods, and copper and brass tubes.

This report, together with specifications for wrought iron for shipbuilding, structural steel for bridges and general construction; material for use in boilers, steel for shipbuilding; material for boiler tubes, practically covers the whole scope of any work that is likely to be done in iron and steel by R.E. officers.

Electrical Work.—There are a number of specifications which deal with this branch of engineering. The report which deals with standards for electrical machinery covers a very wide field in connection with motors, generators, and transformers. There are other reports which deal with supply meters—articles which householders always suspect of telling untruths against them—measuring instruments, such as ammeters and voltmeters, and standards for carbon filament lamps.

Standard of Workmanship.—This has been in many cases a very difficult matter to specify to the satisfaction of both inspector and contractor. Generally in specifications the wording has had to be left loose, in such form as "workmanship to be of the best," or, "entirely to the satisfaction of the inspecting officer." This question has been dealt with very thoroughly in a long series of tests, and the report on "limit gauges" and "errors in workmanship" now make it possible to specify in clearly defined terms the quality of the workmanship, and the extent of allowable and unavoidable errors.

As it is clear that different degrees of accuracy are required in

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different classes of work, different qualities of workmanship are classified under different heads. And it is only necessary to say that certain work has to comply with the provisions for, say, second or third-class work as laid down in Report No. — to make it quite clear that it is possible to allow on the dimensions shown in contract drawings certain tolerances, which are defined as "differences in dimensions proscribed in order to tolerate unavoidable imperfections of workmanship."

The above are only a few notes on the many reports—some 40 to 50 in all—which have been published. These remarks together with a glance at the Tree will show what a great help the standards set up by the E.S.C. may be in practically all classes of engineering work. It is hoped that as these standards become more and more known they will receive greater support than they do at present; and that all who are connected with engineering will do their utmost to help on the good work that is being carried out both at the National Physical Laboratory and by The Engineering Standards Committee.

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THE POSSIBILITIES OF WATER SUPPLY IN LATERITE FORMATIONS.

By CAPT. E. W. S. MAHON, R.E.

ALTHOUGH Sierra Leone has the reputation of possessing a very damp climate, yet, in common with other places in the tropics, it has its dry season during which little or no rain falls for months at a time. In consequence of this there is, during the first months of every year, a great diminution in the volume of the streams supplying the town with water. During the last few years this has practically developed into a water famine in the months of April and May.

The rainy season lasts from about the middle of May till November, and the dry season from December to March; the accompanying chart (see *Plate*) shows both the monthly and the total annual rainfalls for every year since 1882, when the first records were taken. It will be noticed that since 1901 the rainfall has diminished almost uninterruptedly until the present year, 1913, which by September showed no sign of improvement.

This diminution in the rainfall has been attributed to the wholesale clearing of forests and woods, both in the Protectorate and in the neighbourhood of Freetown, and the Colonial Government is attempting to remedy it by preserving and planting certain areas.

Whether this action will have the effect of increasing the general rainfall of the colony remains to be seen. It is, I think, open to question whether it is desirable to do so further than may be necessary for the purposes of water supply and cultivation. A greater rainfall will cause a greater humidity, which will render the climate still more enervating and unpleasant to live in. It is, however, necessary to ensure as far as possible, that the catchment areas which provide the sources of the various Military and Civil supplies should be maintained in the most favourable condition for inducing a maximum precipitation of moisture, and retaining it within them.

To effect this, any portion of the slopes of the spurs and valleys, enclosed within the valleys which are not already wooded, should be planted with quick-growing trees. The crowns at least of all hills which are connected with the areas, should be similarly treated, and steps should be taken to protect the woods from fires and from the encroachment of grass.

Woods increase the natural relative humidity of an area and favour a greater precipitation of moisture. They also serve to retain moisture in the soil, prevent the erosion and denudation of

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the ground, and assist the percolation of water to lower levels, thereby feeding the springs.

Low bush is not so effective as woods and forests for increasing the humidity of a locality because the shade afforded is much inferior, evaporation and radiation are not retarded to the same extent and the temperature differs very little, if at all, from the open country. Moreover, bush does not promote the retention of moisture in the soil to the same degree as forest-land, and is also more liable to destruction by fire. Grass provides less shade again than bush, and has less effect on the humidity of the atmosphere. It does not assist the retention of moisture in the soil or prevent erosion to any extent, especially on sloping ground; and it is still more liable to destructive fires in the dry season. Grass is liable to encroach on forests when in close proximity to them, unless prevented from doing so by cleared belts which fires cannot cross.

Records were taken of two streams in the Kortright Catchment Area at the end of the dry season in 1913, and it was found that the deliveries from them varied enormously in the early morning and at the end of the day. At the beginning of April, while in the morning they discharged at the rate of 1,200 and 250 gallons an hour respectively, by the evening these amounts had fallen to 700 and 100 gallons. At the end of April, the early morning deliveries were at the rate of 700 and 150 gallons an hour and the evening rates were only 450 and 40 gallons.

This shows, that during the day the waters of the streams are absorbed by the ground and vegetation to replace the evaporation of moisture which is taking place. During the night evaporation ceases, moisture is precipitated from the air and relinquished by the ground and vegetation, and the discharge from the streams is increased accordingly. Until 1913 all the water supply systems, both Military and Civil, have depended solely on the discharge of the streams within their several catchment areas for the fulfilment of their requirements. The provision has proved in every case increasingly inadequate as the rainfall has declined.

Although various suggestions have been put forward from time to time for remedying this most undesirable state of affairs, the possibility of obtaining an efficient supply, by tapping an underground source, does not seem to have been considered. But an examination of the geological conditions obtaining in the hills, and observation of the behaviour of the streams during the dry season, led me to the conclusion that there was a great possibility of finding good underground supplies by boring in certain well-defined localities.

The geological formation of Sierra Leone consists primarily of granitic rock, principally in the shape of syenite, which differs from ordinary granite in the absence or scarcity of quartz in its composition. Syenite is composed essentially of an alkali felspar and a

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ferruginous mineral, and is very like a hornblendic granite in structure and appearance. On the slopes, and in the valleys of the hills, the syenite outcrops in well-defined ridges of solid rock, broken, however, by fissures on the surface, and with occasional faults filled with water-worn volcanic conglomerate. Between these ridges of solid rock syenite occurs in boulders, varying both in size and quantity, bedded in, or resting on laterite earth. In some places, the surface of the ground consists of laterite rock alone without any protruding syenite boulders, and the surface of the laterite is covered with a hard ferruginous crust.

Laterite is a clay produced by the decomposition of various rocks in tropical climates, and is especially well developed when the underlying rock is crystalline and felspathic, such as is syenite. The conditions necessary for its formation appear to be a high seasonal temperature and a heavy rainfall, with a well-marked alternation of wet and dry seasons. Laterite occurs in practically every tropical region of the earth, and is very abundant in Ceylon, India, Burma, and Central Africa. In places where the rainfall is more moderate, a calcareous laterite called kunkar is formed; this is much used in India as a hydraulic cement, and I have found it also in the Soudan and up the Yangtse Valley.

The actual decomposition, dissolution, and disintegration of syenite into laterite clay, is most probably due to the chemical action of rain and the acids it absorbs from the air and surface soil soaking into the rock. The formation of the laterite rock, with its hard ferruginous crust, would appear to be due to the reverse action of the water being drawn by capillary attraction to the surface again during the dry season and taking iron in solution with it. The mineral is left behind as an oxide, on and near the surface, as the moisture containing it is evaporated. This hardening only occurs apparently where the laterite can undergo a drying process, and is not found in the beds of valleys which remain moist throughout the year.

When boring through laterite in a valley bed, I generally found a thin layer of Kaolin or China clay just before reaching the hard parent rock. Below the kaolin, the few inches of intervening space contained small particles of decomposing rock, some oxide of iron, and pure sand. The water held in this space was under pressure sufficient to raise it to within a couple of feet of the surface of the ground. In some instances this water was found to contain a thick iron precipitate.

From this it would seem that the formation of kaolin, by the decomposition of the felspar and the liberation of the silica and iron compound, is the first step in the transformation of syenite into laterite; that a thin stratum full of these liberated materials exists between the parent rock and the result of its decomposition, and that this stratum also contains the water which is carrying out the work. As the decomposition proceeds, the silica and iron com-

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pounds previously liberated become re-incorporated with the kaolin, and laterite clay is the result.

In the valleys of the hills round Freetown there are found, as stated above, alternate stretches of laterized ground and ridges of hard syenite rock. The flatter the slopes, the more favourable are the conditions for laterization, and the greater is the extent of the laterized areas in consequence. Laterization does not extend to more than 30 or 40 ft. below the surface of the ground.

The streams which flow in the valleys are fed from springs which occur at the junction of the laterized areas with the syenite ridges. Springs also issue from the hard rock itself, brought from some higher level through fissures and channels formed in the faults of the rock. As the dry season advances, the upper springs gradually diminish, and the bed of the stream in the laterized areas is resolved into a series of pools. The lower springs continue to flow as long as the areas above are over-saturated. In some places where extensive faults occur in the syenite, the whole of the stream may be diverted underground, to reappear perhaps in some other valley. I found an instance of this, where a stream delivering about 500 gallons a day only showed for some 30 yards before disappearing entirely, the valley below being perfectly dry for more than a mile.

The formation of the geological strata in the valleys seems to me to resemble a flight of syenite steps, hollowed out like " basins " and filled to the brim with saturated laterite "sponges." As the process of laterization is always proceeding, the " basins " and the " sponges " in them are being continually enlarged. The water which is carrying out the transformation appears to be held freely as a kind of film in the narrow space between the " sponge " and the " basin," and it therefore seems only natural that boring down through the " sponge " to the " basin " should result in tapping this film of water, which should rise in the bore hole to a height dependent on the level of water at the sides of the " basin."

In April, 1913, acting upon my observations, borings were made at the lower end of Kortright Catchment Area, and a fine supply of water was found, at a depth of only 12 ft. below the surface. It was found possible to add to the existing system at least 25,000 gallons a day from two 4-in. bore holes at the driest season of the year. By this discovery, the problem of the water supply of Tower Hill appears to have been permanently solved.

By comparing the geological conditions obtaining in the Kortright and the other catchment areas, everything seems to point to the great probability of similar underground reservoirs existing in equally favourable positions for adding to the other systems of water supply.

If, as reputed, laterization does not go deeper than 30 or 40 ft., this should limit the depth of the necessary boring. Laterite clay is soft and easily penetrated, and practically the only difficulty to

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contend with is the presence of syenite boulders below the surface in the process of laterization. These boulders have to be avoided, as they are too hard to bore through with ordinary tools.

It must be remembered that the surface of the main rock will have been disintegrated irregularly and that " pockets " may have been formed, so that the best possible results may not always be obtainable at the first attempt. The yields from two holes in close proximity in the same area may also vary considerably, owing to the inequalities of the underground rock affecting the flow of water upon its surface.

There are three distinct systems supplying the troops in the Sierra Leone Peninsula with water. The catchment areas are, however, all situated in offshoots from the same range of hills. The following suggestions regarding them are based on observations which I made while in the Colony, and with the assumption that my theory as to the formation of laterite is correct.

Kortright Catchment Area supplies Tower Hill and King Tom Cantonments. It contains two valleys; the collecting dam, from which the supply is piped to Tower Hill, is situated at the lower end of a ridge of syenite below their junction. The waters of the western branch are absorbed into the ground early in the dry season, but, as the junction of the valleys occurs in an extensive laterized area, it is probable that this stream contributes to the moisture which it contains. The upper waters of the eastern stream are caught about 150 yards below their source and piped to the lower dam. These top springs never fail entirely, but their delivery fell to about 2,000 gallons a day at the end of the dry season in 1913. Below the upper dam, the springs fail gradually during the dry season nearly down as far as the junction of the valleys.

The area is well wooded on the whole, but there are some bare places on the eastern slopes below Kortright and on Havelock Plateau, which might be replanted with advantage.

I think it would be beneficial if the upper waters of the eastern stream were allowed to flow down the bed of the valley, instead of piping them to the lower dam. They would then be utilized in feeding the area with moisture, and probably cause the lower springs to flow more continuously in the dry season. The actual loss, if any, to the system by closing this diversion, will be more than compensated by the gain of moisture to the area. In any case its loss, if any, is immaterial, in view of the large additional supply now obtainable from underground sources. The bore holes from which this additional supply is obtained are situated in a laterized area below the bottom dam, so that the water extracted from them cannot diminish the flow of the stream above it.

Wilberforce Cantonment Supply.—The Catchment Area for this is situated below, and to the south of, Leicester Peak, at the head of the Babadori Valley. The area is well wooded but the slopes of Leicester Peak itself are not. The reservoir, from which the supply

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is piped, is built at the top edge of a big syenite ridge. The streams which feed it run almost entirely through a laterized area. Borings in this area should produce good results. At present the only water caught is that which overflows the " rim of the basin " at the point where the reservoir is built.

Gloucester Catchment Area which supplies Kortright and Mount Aureol gives the worst results of the three systems during the dry season. The delivery fell to about 1,000 gallons a day at one time during April, 1913. Fortunately the requirements are much less than elsewhere, and the supply is capable of improvement. One cause of the poor supply is the fact that the greater portion of the catchment area is bare of all vegetation except grass. This might be remedied by planting trees. But steps would have to be taken early in this direction to prevent the grass encroaching more on the woodland which does exist in the valley, and causing a further diminution in the supply.

In this Area, the impounding reservoir from which the supply is piped to Mount Aureol is built at the bottom of a slope of syenite which is full of faults and fissures ; and, though several springs occur in the bed of the stream, the general surface of the ground is so broken that a large proportion of the water discharging from them disappears into other holes and is lost again underground.

The main stream is caught at the top of this syenite slope and piped down to the reservoir. Above the point where this diversion is made, the valley is flat, and the stream flows through a laterized area from which a supplementary supply could undoubtedly be obtained by boring.

The remedy suggested for the leaks in the ground is to catch each spring at the point where it issues from the rock, and lead it to a main pipe, or channel, delivering into the reservoir. This was tried with beneficial effect last dry season in the case of one spring, but the actual gain was not recorded. This work can only be undertaken in the dry season, and would require careful supervision.

I did not explore the Catchment Areas which provide the Civil water supply. They are all situated in valleys of the same range as the Military Areas. The geological structure of these valleys is similar, and I feel sure that underground reservoirs would be found within them which could be made available for supplementing existing supplies.

In making use of these underground supplies special precautions are necessary for the prevention of waste. They should never be used as a general rule unless required to supplement a deficiency in the ordinary supply, and no more should in any case be drawn off than is required for the time being.

Although, up to the present, experiments have only been carried out in one of the Catchment Areas in Sierra Leone, it is hoped the successful results achieved in this instance should prove of value, by directing attention to the possibility of finding water in "laterized" areas in other parts of the World.

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SIERRA LEONE.

ANNUAL RAINFALLS

1822 1913.

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MONTHLY RAINFALLS

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EARLY INDIAN CAMPAIGNS AND THE DECORATIONS AWARDED FOR THEM.

THE PUNJAUB CAMPAIGN. 1848-9.

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EARLY INDIAN CAMPAIGNS AND THE DECORATIONS AWARDED FOR THEM.

(*Continued*).

By MAJOR H. BIDDULPH, R.E.

THE PUNJAUB CAMPAIGN, 1848–9.

Exactly two years after the close of the 1st Sikh War hostilities again broke out in April, 1848, on account of the murder at Mooltan of Mr. Vans Agnew and Lieut. Anderson by the Dewan Mulraj.

Lieut. H. B. Edwardes with a force composed almost entirely of irregulars at once took the field, and, defeating Mulraj twice, shut him up in Mooltan.

Lord Gough had deferred operations purposely until towards the end of the hot weather, when a force was despatched to the siege of Mooltan under Major-General Whish. A Sikh army from Lahore co-operated, but it threw in its lot with the rebel Mulraj on September the 1st. This compelled Whish to suspend all active offensive operations until he had been reinforced by troops from Bombay and Scinde. They arrived on December the 21st, the siege was again pressed, and the city taken by assault on January the 2nd. The citadel held out until January the 22nd, when Mulraj surrendered himself. Meanwhile the rebellion had spread over the whole Punjaub, and in November the Army of the Punjaub had taken the field under Lord Gough.

The unfortunate cavalry action at Ramnagar (22nd of November) on the left bank of the Chenab was the opening incident of the campaign, in which the 14th Light Dragoons lost their colonel (W. Havelock, brother of Sir H. Havelock), and the cavalry division their general, Brigadier Cureton, the best cavalry officer in India, whose services included the Peninsula War and nearly half-a-dozen wars in India. Among the killed also was the Subadar-Major of the 8th Bengal Light Cavalry—" an old man of 78 years and nearly 60 years' service."

The whole of the army was across the Chenab by December the 8th, and remained inactive till January the 12th, when it moved to attack Sher Singh, who had 30,000 men and 62 guns, near Rasul on the left bank of the Jhelum.

On January the 13th the armies were in contact, but Gough had not intended to fight that day, until it seemed likely that Sher Singh, who had commenced a heavy artillery fire, might take the initiative.

The ground was covered with scrub and jungle, greatly impeding

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vision and co-ordinated movement. The Sikh line, which overlapped the British on both flanks, occupied ground slightly higher than the surrounding terrain. The 2nd Division (Gilbert) was on the right, the 3rd Division (Colin Campbell) on the left, one brigade of which was held in reserve. On the right flank was the 2nd Cavalry Brigade (Pope), and on the left flank was the 1st Cavalry Brigade (White). The 3rd Brigade (Hearsey) was in reserve.

Before the advance began, Colin Campbell told Brigadier Pennycuick that, as the scrub made it impossible for him to effectively superintend the advance of the division, he would leave the leading of the 5th Brigade entirely to him, while he himself would accompany the 7th Brigade (Hoggan) which was dangerously outflanked by the Sikhs.

In the advance Gilbert's division was exposed to the greatest danger; before becoming seriously engaged with the enemy the whole of Pope's cavalry brigade went about, and galloped to the rear, riding over its own horse artillery and causing the greatest confusion.* Pope himself was mortally wounded.

Though taken in flank and in rear Gilbert's division pressed on, repelling all attacks, and carried all before it.

Meanwhile another disaster had befallen the left flank. Pennycuick's brigade inclined to its right front, losing touch with the 7th Brigade; and the centre regiment, H.M. 24th Foot, pressing forward at headlong pace, left the other regiments of the brigade behind. It arrived quite spent and in disorder at the Sikh batteries, was unable to withstand a heavy counter-attack, and was driven back by the Sikh cavalry to a point in rear of that from which it had started, leaving nearly half its number on the ground.

The 6th Brigade (in reserve) was then pushed into the gap formed.

The 5th Brigade with Colin Campbell had advanced steadily in the meantime, and captured the batteries in front with great slaughter; then wheeling to the right it swept along the Sikh position until it joined hands with the left of Gilbert's division.

The Sikhs were driven from the field, but were not routed, and as it was now very late in the day it was considered prudent to withdraw to a more defensible position at Chilianwala. The British casualties amounted to 2,357. The 24th Foot lost in killed or died of wounds 14 officers and 241 men, and had about 250 more wounded. The Sikh loss was enormous. "Never except at Sobraon have I seen so many of the enemy's slain upon the same space," wrote Lord Gough. If only it had been known how broken the spirit of the Sikhs was, the British would have encamped on the field that night. As it was, Sher Singh recrossed the Jhelum in the night, on hearing of the

* It is said that a chaplain in rear was conspicuous in rallying the fugitives, and that Lord Gough wished to promote him "brevet-bishop" for his services.

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British retirement, murdered such of the wounded as had been left behind and recovered most of his guns.

The temper of the British troops did not permit of renewed action on the morrow and Lord Gough awaited the fall of Mooltan, which occurred a few days later, when General Whish with all the Bengal Division, and one strong Bombay brigade, marched to join him. The last of these troops joined Gough on February the 20th. In the meantime Sher Singh, who had received very numerous reinforcements, retired and established himself at Goojerat, with 60,000 men and 59 guns.

On February the 15th, Gough marched from Chilianwala, detaching a force to Wazirabad to prevent any raid across the Chenab on Lahore.

On February the 21st, the attack on the Sikh position at Goojerat began with a heavy cannonade which was maintained until the Sikh artillery was overpowered, and their whole line badly shaken. The infantry now advanced, the 1st and 2nd Divisions on the centre of the position, the 3rd Division on the left of the line, and cavalry on both flanks. By one o'clock, after a desperate resistance, the whole Sikh army was in full flight, leaving 56 guns and numberless dead on the field. The pursuit continued for 15 miles that day, and on the morrow Gilbert resumed it with such persistence and relentless vigour that on March the 14th the Sikh chiefs and the remnant of their armies surrendered to him at Rawal Pindi, giving up 41 guns and 20,000 stand of arms. As some allied Afghan cavalry had fought with the Sikhs, Gilbert continued his pursuit to Peshawar, where the remnants of the Afghan cavalry fled through the Khyber Pass.

The whole of the Punjaub was annexed to British India as the result of the war.

The medal for this campaign was authorized in the first instance by Lord Dalhousie, and was given to all troops serving in the Punjaub; the clasp for Chilianwala was granted later at Lord Gough's personal request.

PUNJAUB CAMPAIGN, 1848–9.

Medal 1·4.-in. diameter, silver.

Obverse.—Crowned head of Queen Victoria. Legend "Victoria Regina."

Reverse.—The Sikh army laying down its arms before Sir W. R. Gilbert and his troops near Rawal Pindi. Inscription "To the Army of the Punjab." In exergue "MDCCCXLIX."

Clasps.—"Mooltan."
"Chilianwala."
"Goojerat."

Mounting.—Silver scroll bar and swivel.

Ribbon.—Dark blue with two thin yellow stripes, 1¼ in. wide.

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Nobody earned the medal with three clasps, but Sir H. M. Lawrence received the medal with two clasps, " Mooltan " and " Chilianwala." He was returning to Lahore from leave in England, and travelling *viâ* Karachi and the Indus, spent a few days *en route* at Mooltan, during the last phase of the siege. This combination is, I believe, unique.

The medal with single bar " Mooltan " is not very common to those corps which served at Goojerat as well, *e.g.* the 1-60th Rifles with a strength of nearly 1,000 received less than 100 medals with this one bar, and it is not an uncommon thing to come across a medal to this regiment from which the Goojerat bar has been removed with great care. The irregular levies did not receive any medals.

All the troops quartered in the Punjaub received the medal without the clasp, even if not engaged with the enemy, so that in all some 60,000 medals were issued, with nearly 19,000 clasps for " Mooltan," over 20,000 clasps for " Chilianwala," and about 34,000 clasps for " Goojerat."

The troops who received the medal only were as follows :—

Bengal Horse Artillery :—2-1st, 3-1st, and 3-3rd Brigade.
Bengal Foot Artillery :—1-5th, 1-6th, 3-6th, 4-6th, 2-7th, 4-8th and 6-8th Battalion.
7th Bengal Cavalry ; 2nd, 13th, 15th, 16th and 17th Irregular Cavalry.
Bengal Pioneers :—1st Co.
Bengal Native Infantry :—1st, 3rd, 4th, 18th, 22nd, 29th, 37th, 50th, 53rd, 71st and 73rd N.I.
Local Corps :—1st and 2nd Regts. Sikh Local Infantry.
Details of the Indus Flotilla, and of corps in the field.

The troops present at Mooltan, Chilianwala and Goojerat were as follows :—

Troops present at the Siege of Mooltan (18th August, 1848, to 22nd January, 1849. Major-General W. S. Whish, Bengal Artillery, in command).

Bengal Column.

Artillery :—Major H. Garbett.
4-1st Brigade and 4-3rd Brigade Horse Artillery.
2-2nd Battn., 3rd and 4th Cos., 3rd Battn. and 6-7th Battn. Foot Artillery.
Engineers :—Major R. Napier, succeeded by Brigadier J. Cheape.
1st, 2nd and 3rd Cos. Sappers & Miners.
2nd and 3rd Cos. and detail of 5th Co. Pioneers.

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Cavalry :—Lieut.-Colonel H. F. Salter, 11th Light Cavalry.
11th Light Cavalry.
7th and 11th Irregular Cavalry.
Detachment 14th Irregular Cavalry.
1st Infantry Brigade :—Lieut.-Colonel A. Hervey, 52nd N.I.
H.M. 10th Foot.
8th and 52nd Native Infantry.
2nd Infantry Brigade :—Lieut.-Colonel F. Markham, 32nd Foot.
H.M. 32nd Foot.
49th, 51st and 72nd Native Infantry.
Detachment of the Guides (Lieut. H. B. Lumsden), Sikh contingent under Lieut. H. B. Edwardes, and Bahawalpur contingent under Lieut. E. J. Lake.

Bombay Column.—Brigadier the Hon. H. Dundas (arrived 21st December, 1848).

Artillery :—Major J. S. Leeson.
3rd Troop Horse Artillery.
2-1st Battn., 4-2nd Battn., 1-4th Battn. and 2-4th Battn. Foot Artillery.
Engineers :—Major W. Scott.
1st and 2nd Cos. Sappers & Miners.
Cavalry :—1st Light Cavalry.
1st and 2nd Scinde Irregular Horse.
Infantry :—1-60th Rifles, 1st Bombay Europeans.
3rd, 4th, 9th and 19th Native Infantry.
Scinde Camel Baggage Corps.
Indus Flotilla :—Capt. F. T. Powell.
Casualties of the Regular Forces :—
9 British officers and 201 other ranks killed.
55 ,, ,, ,, 927 ,, ,, wounded.

The number of shot and shell fired during the siege was 42,193; but it is uncertain whether this includes the ammunition expended by the Bombay Artillery. At the Siege of Bhurtpore, which lasted 5 weeks, December, 1825, January, 1826, the expenditure was 61,446 shot and shell.

Troops present at the Battle of Chilianwala, 13th January, 1849 (Lord Gough, C.-in-C.).

Cavalry Division :—Major-General Sir J. Thackwell.
1st Brigade :—Brigadier M. White, 3rd Light Dragoons.
H.M. 3rd Light Dragoons.
5th and 8th Bengal L. Cavalry.

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2nd Brigade :—Brigadier A. Pope, 6th Bengal L. Cavalry.
H.M. 9th Lancers.
1st and 6th Bengal L. Cavalry.
H.M. 14th Light Dragoons (attached).
3rd Brigade :—Brigadier J. B. Hearsey (in rear with the baggage).
3rd and 9th Irregular Cavalry.

Bengal Artillery :—Brigadier J. Tennant.
2nd Brigade Horse Artillery, 1st, 2nd, 3rd and 4th Troops.
3rd Brigade Horse Artillery, 1st and 2nd Troops.
1st Battn. Artillery, 1st and 3rd Cos.
4th Battn. Artillery, 1st, 2nd and detachment of 4th Cos.
7th Battn. Artillery, 3rd Co.

Bengal Engineers :—Major G. B. Tremenheere.
4th, 5th, 6th and 7th Cos. Pioneers.

2nd Infantry Division :—Major-General Sir W. R. Gilbert.
3rd Brigade :—Brigadier C. Godby, 2nd European Regt.
2nd Bengal European Regt.
31st and 70th Bengal N. Infantry.
4th Brigade :—Brigadier A. S. H. Mountain, 29th Foot.
H.M. 29th Foot.
30th and 56th Bengal N. Infantry.

3rd Infantry Division :—Brigadier C. Campbell,* 98th Foot.
5th Brigade :—Brigadier J. Pennycuick, 24th Foot.
H.M. 24th Foot.
25th and 45th Bengal N. Infantry.
7th Brigade :—Brigadier J. Hoggan, 45th Bengal N. Infantry.
H.M. 61st Foot.
36th and 46th Bengal N. Infantry.

In reserve :—6th Brigade :—Brigadier N. Penny, 69th Bengal N. Infantry.
15th [20th] and 69th Bengal N. Infantry.

With the Baggage Train :—Brigadier J. B. Hearsey.
3rd and 9th Irregular Cavalry.
20th Bengal N. Infantry.
3 guns 1-1st Battn. Artillery.

Casualties :—

22	British officers and		580	other ranks	killed.
67	,,	,,	1,584	,,	,, wounded.
			104	,,	,, missing.

Casualties of H.M. 24th Foot :—
14 officers and 241 men killed.
10 ,, ,, 253 ,, wounded.
12 guns were captured.

* Afterwards Lord Clyde.

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Troops present at the Battle of Goojerat, 21st February, 1849 (Lord Gough, C.-in-C.).

Cavalry Division :—Sir J. Thackwell.
1st Brigade :—Brigadier M. White.
H.M. 3rd Light Dragoons.
H.M. 9th Lancers.
8th Bengal L. Cavalry.
Scinde Irregular Horse.
2nd Brigade :—Brigadier G. H. Lockwood, 3rd Light Dragoons.
H.M. 14th Light Dragoons.
1st Bengal L. Cavalry.
11th and 14th Irregular Cavalry (each 2 rissalas).
3rd Brigade :—Brigadier J. S. Hearsey.
3rd and 9th Irregular Cavalry.
Bengal Artillery :—Brigadier J. Tennant.
Horse Artillery :—1st Brigade, 4th Troop ; 2nd Brigade, 1st, 2nd, 3rd and 4th Troops ; 3rd Brigade, 1st, 2nd and 4th Troops.
Foot Artillery :—1st and 3rd Cos. 1st Battn. ; 2-2nd Battn. ; 3rd and 4th Cos. 3rd Battn. ; 1st, 2nd, and detachment 4th Co. 4th Battn. ; 3rd and 6th Cos. 7th Battn.
Bombay Artillery :—Major J. S. Leeson.
3rd Troop Horse Artillery.
2-1st Battn. (in reserve).
Bengal Engineers :—Brigadier J. Cheape.
2nd and 3rd Cos. Sappers & Miners.
2nd, 3rd, 4th, 5th, 6th and 7th Cos. Pioneers.
Bombay Engineers :—Lieut. W. Kendall.
1st Co. Sappers.
1st Infantry Division :—Major-General W. S. Whish.
1st Brigade :—Brigadier A. Hervey, 52nd N.I.
H.M. 10th Foot.
8th and 52nd Bengal N. Infantry.
2nd Brigade :—Brigadier F. Markham, 32nd Foot.
H.M. 32nd Foot.
51st and 72nd Bengal N. Infantry.
2nd Infantry Division :—Sir W. R. Gilbert.
3rd Brigade :—Brigadier N. Penny.
2nd Bengal European Regt.
31st and 70th Bengal N. Infantry.
4th Brigade :—Brigadier A. S. H. Mountain.
H.M. 29th Foot.
30th and 56th Bengal N. Infantry.
3rd Infantry Division :—Brigadier C. Campbell, 98th Foot.
5th Brigade :—Brigadier A. Carnegy.
H.M. 24th Foot.
25th Bengal N. Infantry (and 45th Bengal N. Infantry in reserve).

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6th Brigade :—Brigadier J. Hoggan.
15th and 20th Bengal N. Infantry (in second line).
(69th Bengal N. Infantry in reserve).
7th Brigade :—Brigadier A. McLeod, 61st Foot.
H.M. 61st Foot.
36th and 46th Bengal N. Infantry.
Bombay Division :—Brigadier Hon. H. Dundas.
H.M. 1-60th Rifles.
1st Bombay European Regt.
3rd and 19th Bombay N. Infantry.
Scinde Camel Baggage Corps.
Reserve :—Lieut.-Colonel A. Mercer, 69th Bengal N. Infantry.
5th and 6th Bengal L. Cavalry.
2-1st Battn. Bombay Artillery.
45th and 69th Bengal N. Infantry.
Also present a detachment of the Guides.
Casualties :— 4 British officers and 91 other ranks killed.
25 ,, ,, ,, 681 ,, ,, wounded.
56 guns were captured.

Detached Force near Wazirabad, commanded by Lieut.-Colonel J. Byrne, 53rd Foot.

12th and 13th Irregular Cavalry.
4 guns 6-7th Battn. Bengal Artillery.
H.M. 53rd Foot.
13th Bengal N. Infantry.

On the evening of the 21st February, this detached force had arrived within a few miles of the right rear of the British Army. They received the clasp for Goojerat, with the exception of the 13th Irregular Cavalry, which was probably further to the rear.

Engineer Officers who served in the Punjab Campaign, 1848–9.

Bengal Engineers.

M.G. Major-General J. Cheape, C.B. Chief Engineer.
C.G. Capt. G. B. Tremenheere.
M.G. Bt. Major R. C. Napier. (Wounded. Chief Engineer at Mooltan till December, 1848).
C.G. Capt. J. Glasfurd.
C.G. ,, B. W. Goldie.
C.G. ,, H. M. Durand.
M.G. ,, W. Abercrombie.
M.G. ,, J. R. Western.
M.G. ,, H. Siddons.
C.G. ,, A. Cunningham.
C.G. Lieut. C. B. Young.

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C.G. Lieut. R. Baird Smith.
C.G. ,, A. G. Goodwyn.
C. ,, H. Yule.
C.G. ,, T. S. Irwin.
C.G. ,, W. E. Morton.
M.G. ,, J. H. Maxwell.
M.G. ,, E. J. Lake. (Political employ).
M. ,, P. Garforth.
G. ,, W. A. Crommelin.
M. ,, G. W. W. Fulton.
M.G. 2nd Lieut. A. Taylor.
M.G. ,, A. Fraser. (Adjutant).
M. ,, C. S. Paton.
M.G. ,, T. G. Glover.
M. ,, H. Hyde.
M. ,, R. Young.
M.G. ,, B. M. Hutchinson. (Mortally wounded at Battle of Goojerat).
M.G. ,, F. C. Grindall.
M.G. ,, W. W. H. Greathead.
M.G. ,, W. S. Oliphant.
M. ,, H. W. Gulliver.
M.G. ,, C. Pollard. (Wounded).
M.G. ,, C. T. Stewart.
M.G. ,, F. R. Maunsell.
M. ,, A. W. Garnett.
M.G. ,, D. C. Home.

Bombay Engineers.

M. Major W. Scott.
M. Lieut. Jno. Hill.
M.G. ,, Wm. Kendall.
M. ,, H. P. B. Berthon.
M.G. ,, J. T. Walker.
M. ,, J. W. Playfair.
M. ,, J. A. Fuller.

M denotes clasp for the Siege of Mooltan.
C denotes clasp for the Battle of Chilianwala.
G denotes clasp for the Battle of Goojerat.

Medal without Clasp.

Major H. Goodwyn.
Capt. J. R. Oldfield.
Lieut. J. T. Donovan.

(*To be continued*).

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REVIEWS.

GUIDE DE L'OFFICIER CHARGÉ DES COMPAS.

By CAPT. LOUIS MOTTEZ.

THIS is a highly technical publication for the guidance of officers placed in charge of the magnetic compasses on board ship. The first part is mainly theoretical and deals with magnetic fields, Faraday's laws, the magnetic properties of hard and soft iron bars and spheres, their fields, induction, terrestial magnetism, the periodical and diurnal variations of the compass, the magnetic effects of iron ships, formulæ for compensation when the vessel is erect, the effect of heel and its compensation.

The second part is practical, and contains extracts from the regulations laid down for the care and preservation of the compass, records to be kept, descriptions of the various operations to be undertaken in harbour and on the high seas for adjusting the compasses, the calculations to be made, and the application of their results. The treatise is based on 20 years' experience at sea, and appears to be thoroughly practical.

A.R.R.

L'EVOLUTION DE LA MARINE AMERICAINE.

By CAPT. H. DE ROQUEFEUIL.

THIS is a careful study of the recent changes in the American Navy, under which the engineer branch was amalgamated with the executive branch on board ship, and, to a considerable extent, in the arsenals on shore. The change was first introduced in 1899, and was a direct consequence of the war with Spain, due to the dangerous scarcity of naval officers at the outbreak of that war. From that date onwards to the present time the writer traces the progress and results of the amalgamation, and of the altered conditions of training and service which were then instituted, and modified later as experience dictated improvements in the original scheme.

Great Britain has adopted an almost similar scheme, and the tendency of all European nations lately has been towards unity of corps as distinct from a too strict specialization, though in no case have reforms been pushed so far as in the United States and in Great Britain. A separate chapter is devoted to a discussion on the " machinists," or mechanists, whom it was found necessary to engage for the engine room on the suppression of the distinct engineer officer. Another chapter contains a description of the Naval School at Annapolis, and of the course of instruction pursued at that institution.

The study is well compiled and appears to be very complete. Reference is given by footnotes to speeches in the American andBritish Houses of Parliament, or to articles in magazines and books from which infor-

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mation has been drawn. The writer is evidently a partizan of the reform, still the arguments for and against the movement are stated on the whole impartially, and the publication is a useful contribution to the discussion, particularly for the general reader who wishes to keep in touch with current topics and has not the time or opportunity to search through all the multifarious documents bearing on the question.

A.R.R.

QUESTIONS DE CRITIQUE MILITAIRE ET D'ACTUALITE.

By GENERAL H. BONNAL.

A COLLECTION of some 20 short articles on military subjects, evidently written by one who has at heart the best interests of his country. They are worthy of perusal as illustrations of French military aspirations at the present day. Criticism, where indulged in, is moderately expressed, and should not fail to be of use if read in the spirit in which it is offered. We may be allowed to express a hope that it will be accepted in this spirit, and that it will be productive of the best results, so that if, and when, the struggle in which the French nation is even now engaged is to be put to the test of actual war, its fine army may be found fully prepared to uphold its high reputation.

Amongst others are articles on the following subjects :—

Napoléon chef d'armée.
Napoléon et son Quartier général.
Napoléon foyer d'heroisme.
Deux armées rivales.
Comme à la veille d'Iéna.
Bazaine le 18 Août, 1870.
L'Armée française aux Manœuvres de l'Est en 1911.
Deux méthodes de Commandement.
Paix ou guerre ?
Le général de Ladmirault à Rezonville.
Le général de Charette.
Aeroisme et Faiblesse.
L'Aviation militaire.
Pour la sécurité des Aviateurs.
La guerre aérienne.

A.R.R.

THE RAILWAY ENGINEER'S FIELD BOOK.

By MAJOR G. R. HEARN, R.E., AND A. G. WATSON, C.E.

(Thacker Spink & Co., Calcutta and Simla. Price 20s. Thacker & Co., 3, Creed Lane, London, and Bombay).

PROPERLY understood, no better description of this book can be given, than that of the authors, on the title page, " A Practical Manual for Engineers in the East."

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It is practical in that the authors have practised what they preach and know and describe exactly how work is done in the field. Sufficient theory is given to explain the principles on which the practice is based.

The word manual, it should be noted, is used in its true sense, *i.e.*, a book to keep at hand, not in the sense of an elementary primer, as the book is more in the nature of a pocket treatise, containing as well all the tables usually required in the field.

It divides itself naturally into four parts :—

1st. A description of the instruments used, *and their adjustments.*

2nd. How to use them to the best advantage in every class of railway survey.

3rd. Hints on reconnaissance and considerations on location showing how many factors enter into the selection of the best line.

4th. A full description of the actual work of staking out the line in the field, with a chapter on circular curves, another on transition curves, and some notes on solar observation for time and azimuth. Chapter 5 is, in effect, a short treatise on the use of the tacheometer, an instrument that has not been used to any extent in India up to date, but one which appears to be, in the hands of a thoroughly competent man, an ideal instrument for surveys in rough countries.

The appendix contains many tables, such as ordinates, abscissæ of curves, tangents (to every minute), logs of numbers, log functions of angles, and tacheometer tables.

Chapters 3 and 7 are particularly important, as pointing out how numerous and varied are the factors which have to be considered in the choice of the best line (there can only be one best line) and insisting on the value of a careful reconnaissance, before any detailed work is commenced. These chapters will be found to contain much that is new to most of us, and even those engineers well experienced in railway survey will probably find them useful as an aide-memoir, and of great assistance in the issue of orders to subordinates. Not the least useful point brought out in this book, is the fact that a thorough knowledge of the methods of surveying is only the first *qualification* for the railway surveyor, so many and varied are the considerations determining the location of the line.

This book, being written from experience in India (and the only one so written), is particularly useful to R.E. officers proceeding to India, containing as it does a complete description of the organization and work of a survey party, and instructions as to the best way of recording observations in the field, so that they may be easy to find during plotting —a point of no little importance. It is a book to keep at hand both in the field and in the office, and has been described by the Chief Engineer of the Railway Board as one which should be in the library of every engineer.

C. ST. J. LYNCH, *Capt., R.E.*

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NOTICES OF MAGAZINES.

Revue d'Artillerie.

November, 1913.

Contribution to the History of the Artillery.

The Extraordinary Commission of the Year 'XI.—This commission was convoked by the First Consul with the object of simplifying the heterogeneous patterns of guns in use at the end of the 18th century. The minutes of the first sitting are given. Of historical interest only.

Notes on the Employment of Artillery in the Balkan War.

An extract from notes made by Capt. G. Bellenger of the Artillery, who, with Colonel Mondesir of the Engineers, visited the theatre of war last April. It is published with the reservation that no responsibility is accepted for the opinions expressed.

1. *Siting.*—After Kirk Kilisseh the Bulgarians were generally in action on gentle slopes only, and took up positions well behind the crests, necessitating communication by telephone with the observing station. The Turks usually declined the artillery combat so that the Bulgarians only had to support their own infantry. The slowness of communication often militated against the timeliness of the salvos. The Servians in Macedonia, fighting on steep slopes, drew nearer to the crests, and elected to do so even at Kumanovo and Monastir although there was no great reason for it except that rapid fire could more easily be directed. The Greeks did not choose high screens. Many of the Turkish batteries seemed to be unacquainted with the use of indirect fire.

2. *Occupation of the Position.*—All the belligerents agree that a battery seen on the move is lost. The Bulgarians were so careful that their guns advanced under cover that they frequently opened at 5,000 metres or beyond. At Lule Burgas there were good artillery positions that could have been occupied at 2,000 to 3,000 m. range on condition that the intervening ground was crossed by night, but no attempt was made to do so. The Servians, on the contrary, probably because their artillery was better horsed, took advantage of the cover of night to make advances of 1,500 to 2,000 m., though occasionally they had the misfortune to find that the new position was in full view of the enemy by day. A case is mentioned of a battery thus in sight not being annihilated.

3. *Ranging.*—The officers consider that regularity in the distribution of fire is not necessary, the lines of fire must all be directed upon the important points of the objective. The Turks used one gun for ranging; this is decidedly a mistake as this gun was usually sacrificed at once.

4. *Execution of Fire.*—All agree that shell were generally burst too high. This was probably due to the long ranges, and consequent irregu-

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larity in the range, and times of burst. Shrapnel and explosive shell were equally dreaded by the infantry. Searching fire was seldom employed.

5. *Effects of Fire.*—The Servian claim that they frequently destroyed hostile batteries could not be substantiated. In Thrace such an effect seems to have been very rare, but cases of neutralization and immobilization frequent, but then the Turks always entrenched, and three-quarters of them were, as a rule, untrained reservists. Except in a few instances when they attacked bravely, their immobility may have been as much due to faults in their organization as to the enemy's guns. The Bulgarians always entrenched even their reserves as soon as they came under shell fire, but their trenches were often constructed for shelter only, and had no field of fire. The Servians sited their trenches much more skilfully, with a view to a possible offensive return of the enemy. On all sides the great moral effect on the infantry of support by shell fire was insisted upon; in many cases this must have been its only effect.

6. *Objectives, and Nature of Shell.*—In no case was any systematic fire employed against buildings or woods, as they hardly existed. Earthworks were frequent; the Bulgarians dealt with them by time-fuzed shell and night attacks with the bayonet. The Servians carried some by day by dint of well-combined action of both artillery and infantry. As an example of the effect of artillery fire at long ranges, it is reported that at the Battle of Ganitze-Vardar the Turks for a long time prevented the passage of a bridge 6·2 k.m. (3 miles 7 furlongs) away. The Bulgarians and Servians both assert that a battery in the open can always be smashed by a masked battery, but see above, *Section* 2. It is observed that the batteries destroyed were nearly always exposed to oblique or enfilade fire. Fire on masked batteries appears to be of little effect. It would be better to support directly one's own infantry, and enable them either to attack the battery, or to cover some more advantageous artillery position. If these two solutions are impossible the artillery fight is prolonged with no definite result. No use was made of aeroplanes in this campaign.

7. *Distribution of Artillery to the Other Arms.*—The Bulgarian division corresponds to the French *corps d'armée* (24 battalions) but with an addition of one-tenth for losses. With each division are 3 groups each of 3 batteries of 4 guns, or 36 Q.F. guns against 120 in the French Army. Each artillery regiment also mobilizes a second regiment of 6 batteries of six 87-m.m. (3½-in.) Krupps, but these seem to have been all concentrated at the Siege of Adrianople. The Bulgarian divisional artillery, however, does not correspond to the corps artillery, to be kept at the disposal of the commander, but was generally divided amongst the three brigades. Brigadiers, again, generally split it up to such an extent that single guns had often each its separate objective. Except at Adrianople, no concentrated powerful mass of artillery was ever employed in action by the Bulgarians, and there is no battle of theirs in which the artillery can boast of having taken a really decisive part. This is probably due to lack of teams in time of peace and the consequent want of practice in manœuvre. The Servians have the same number of guns in their division of 16 battalions, and their generals did not split them

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up but kept them in reserve or employed them at a decisive point. On one occasion guns not required were lent to a neighbouring division.

8. *Expenditure of Ammunition.*—No figures are given, but it is said to have exceeded all estimates, and replenishment was a great difficulty. The halts of the Bulgarians after Lule Burgas, and of the Servians after Kumanovo, seem to have been in a great measure due to insufficiency of gun ammunition.

9. *Heavy Artillery and Howitzers.*—The advantages of curved fire were never utilized by Bulgarians or Servians, who only looked on their heavy artillery as long-range guns with powerful shell. Both had 120-m.m. (5-in.) long guns as well as howitzers. Except at Adrianople and Chatalja the Bulgarians only used their howitzers at Bunar Hissar, and then only because the situation was so critical that every available resource had to be employed. The Servians only used heavy guns at Monastir to support their infantry from behind an extensive inundation. The 120-m.m. long guns were used on one occasion against a mountain position which the field guns could not reach, and caused the Turks much alarm as they thought themselves beyond artillery range. The writer expresses a doubt whether heavy guns and ammunition are worth the trouble of conveyance, and argues his point at some length.

Mechanical Fuzes.

In this third and last part the details of certain parts of the mechanism are described, *e.g.* safety appliances, the trigger, and the striker. As examples of the first the fuzes of Meigs, Nordenfeldt, Klumach and Walsh have been taken, and of the second the fuzes of Maxim, Nordenfeldt, Kelsen and Micciche, and of the third those of Baker, Smith and Wetter.

The final conclusion is that the clockwork fuze realizes an important progress, but is not yet perfect. If a fuze is required that can be regulated to 15 metres, then for a residual velocity of 300 m.s. an accuracy of $\frac{1}{20}$th second is necessary. This accuracy cannot yet be guaranteed with mechanism of such small dimensions, which must also be strong enough to stand rough usage, and the shock of discharge.

German Tendencies at the Present Day in Regard to the Employment of Heavy Artillery.

The German foot artillery has been considerably augmented since 1911. It is clear that the heavy gun is to be a true field weapon, working in conjunction with the other arms. This is evidenced by the recent corrections in the foot artillery regulations (*Provisional Regulations*, 1908, Chapter IV.—The Combat). The author quotes the text of the revised paragraphs, and adds extracts from comments made in regard to them by different German writers. The article is well worth perusal. The conclusions arrived at are :—

1. Under favourable circumstances the heavy artillery will come into action at long ranges before the actual battle commences, to delay the enemy and oblige him to deploy, to deny him defiles which he is bound to try to make use of, to disturb his assemblies, to hinder the arrival of his artillery, etc. To these ends it will be placed further forward than hitherto in the line of march.

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2. The principal duty of the heavy artillery is to annihilate early the enemy's artillery, and thus leave the greater part of the field artillery directly free to support the infantry. With this object in view it will be placed as much as possible in the centre of the front, behind the field artillery if necessary. It can disable guns with shields even when they are completely masked—provided the zone in which they are stationed is known—by systematic fire within the limits of that zone. It requires time and ammunition to do so, but these need not be grudged, as the quantity of ammunition with the battery (1,728 rounds) enables the result to be obtained without unduly exhausting the supply.

3. Afterwards the heavy artillery will support the infantry, especially when it encounters a fortified position; in particular it will participate in the final blow which will render the zone selected for the decisive attack ripe for assault. It will then continue to fire up to the extreme limit permissible by considerations of the safety of its own troops.

CUTTING PROPERTIES OF TOOL STEELS.

This article is concluded. The practical application of the curves obtained from the testing machine are explained. It must be remembered that these curves are only applicable in the workshop if the same material (hard or soft metal) is worked as was used in obtaining the curve in the testing machine. Different curves must be made for different metals. From these different curves co-efficients are obtained, for the same quality of tool steel, so that if the best speed to employ for cutting any particular metal (phosphor bronze, for instance) has been obtained by the testing machine, then the best speed for the same steel cutting any other metal (hard steel, or cast iron, say) can be readily calculated.

The output of any particular quality of tool-steel cutting any particular material, remains constant if the three variables, speed, depth, and width of cut, remain constant. This relation is expressed by the formula aSV^3=constant, or a^2lV^3=constant, where a=the depth of cut, S the area of the section, l the width of the cut, and V the speed in metres per minute. From this formula a table is calculated on which can be easily read off the co-efficient by which the speed must be multiplied when the width or depth of cut, or both, is altered, if the maximum output is still required.

It does not necessarily follow that the speed giving the maximum output of a tool is the most economical speed in every case. If a number of articles of exactly the same dimensions is to be prepared, it is better to use the speed that will give the maximum output of the tool, as the frequent removal of the tool for sharpening means alteration in its shape and consequent delay in adjusting it again exactly to the same depth of cut. But if a given quantity of material has to be removed from a large piece of metal it is more economical in point of time, and therefore of money, to use a quicker speed within certain limits, and to sharpen the tool more frequently. This question of the economical speed is fully entered into, and several examples are given.

Chapter II. deals with carbon and special steels in the same manner

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as has been adopted in Chapter I. for high speed steels, and similar curves and tables of co-efficients are worked out for these steels.

Chapter III. recapitulates the former chapters and states shortly the general conclusions arrived at.

Various Information.

A list is published of the changes in station of the headquarters and various groups of artillery in France from 1st April, 1914.

The spring washers invented by Mr. J. Reiss for bolts subjected to vibration are described and illustrated.

United States.—Field Artillery v. *Aircraft.*—For several years various special cannon have been experimented with, but now it is considered that the introduction of a special weapon would be a mistake, since it is the field artillery which will most often be confronted with this nature of target. The carriage of this gun—model 1902—will therefore be subjected to further modifications to fit it for use against aircraft.

A.R.R.

Revue Militaire Suisse.

November, 1913.

The Communications of the Grand Army in 1806-07.

Many of the boldest conceptions of Napoleon were based on a change in his line of communications, which he defined as "an operation of genius" and "the cleverest manœuvre taught by the art of war," owing to the way in which it misled the enemy. The plan evolved by the Emperor in September—October, 1806, is one of the most remarkable examples which exist of the use of lines of communications. Ostensibly, at the commencement of the campaign, a main line of communication was organized, while at the same time several others were prepared. The first was merely a lure to attract into Hesse a portion of the enemy's forces, while Napoleon cut off the Prussians from the Elbe by marching direct from Bamberg on Berlin, based on other lines of communication.

Prior to 1806 the French armies lived on the enemy's country; in 1805 (Austerlitz), when larger numbers of troops were employed, great privations had to be endured. In 1807 Napoleon had at one time to yield to necessity and arrange for convoys and supply depôts, but he refused them the next year in Spain. Still the army, although relieved from daily anxiety in regard to its provisions, had yet to be followed by trains of ammunition, reinforcements of men and *matériel*, couriers, etc. To this end the Emperor, directly his plan of campaign was settled, decided on a line of communication which he also called *route de l'armée*, but on principle he never left behind any line of communication troops. Relative security, he considered, should be maintained by moral persuasion, by the responsibility of the communes, by hostages, and by activity of administration. Only large, well-escorted convoys, despatched at irregular intervals, traversed the route, while sick and wounded were cared for in the conquered territory. At every four to six marches a strong position was selected, and organized for defence

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by means of fieldworks. The garrisons were composed of conscripts, horseless cavalry, convalescents, and contingents furnished by allies, commanded by a convalescent or sick general, or other superior officer. Although these places could not withstand a siege, they served to shelter magazines, depôts, wounded, etc., and in them convoys could be reorganized and find provisions, ammunition, workshops, hospitals, etc. Thanks to this system Napoleon could abandon his line of communications to itself for days together.

The campaign selected to illustrate this principle and the change in the line is then related, commencing with the European situation at the beginning of September, 1806. It is illustrated by a map, and the events up to the end of September are traced in this number.—(*To be continued*).

MILITARY AVIATION IN SWITZERLAND.

By Lieut.-Colonel Et-Ed. Borel.—An account of what has been accomplished to date, with remarks on the particular qualities required of both aeroplanes and pilots in a mountainous country. The greatest difficulties encountered are changeable winds, mists, the restricted area of most of the landing places, and troubles of communication. The writer was in charge of the aviation services at the recent manœuvres, and describes the results obtained and makes suggestions for ensuring greater efficiency on future occasions.

THE BATTLE OF CRESSIER.

The imaginary attack of this position is continued, step by step. The reasons given for the dispositions adopted for the various troops are sound and instructive.—(*To be continued*).

A.R.R.

RIVISTA DI ARTIGLIERIA E GENIO.

September, 1913.

AUSTRIA-HUNGARY.

New Dirigibles.—According to the *Aérophile* of the 15th July the war minister of Austria-Hungary has given orders for six dirigibles (Zeppelin), which should be supplied in 1915. These airships are destined for Vienna, Prague, Lenberg, Innsbruck, Budapest, and Sarajevo.

Changes in Military Institutions.—We learn that changes in the Austrian-Hungarian military institutions have taken place in recent years. In fact in 1910 the Military Technical Academy was created for officers destined for the troops of communication; and from the end of the current year provision has been made at the said Academy for all the officers for railways and telegraphs.

The *Revue Militaires des Armées Étrangères* of July states also that admission to the school of pioneer cadets at Hainberg is suspended, and that from the beginning of the year 1913–14 the course for pioneers of the Military Technical Academy may be transferred from Mödling to Hainberg. In consequence of the approaching subdivision of engineer

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troops into pioneers and sappers, a special course for sappers will be instituted at the Academy of Mödling. At the commencement of 1916 the officers of pioneers and sappers will all come from the Technical Military Academy. The modern tendency in Austria-Hungary is to constitute for all the arms a homogeneous body of officers coming from the Academy, with a grade of general and technical instruction superior to that of the officers coming from the school of cadets.

Military Commands of Lines.—The *Revue Militaire des Armées Étrangères* of July also states that the number of military commands of lines in Austria-Hungary is increased to 26. The commandants of lines are superior officers, and remain in charge for not less than six years.

They have as collaborator a railway functionary (*Militär-Referent*) who takes the place of the commandant of lines during his absence. The commands of lines are at the following stations :—

1, 2, 3, 4, 5	Vienna.	17	Szombathely.
6.....	Linz.	18	Miskoloz.
7.....	Innsbruck.	19	Szegedin.
8	Villach.	20	Debrezen.
9	Trieste.	21	Kolozsvar.
10	Pilsen.	22	Arad.
11	Prague.	23	Agram.
12	Cracovia.	24	Temesvar.
13	Lenberg.	25	Szabadka.
14	Stanislao.	26	Sarajevo.
15, 16	Budapest.		

Belgium.

Organization of the Engineers.—*La France Militaire* of 27th—28th July states that owing to the new organization, the corps of Belgian engineers comprises :—

(*a*). An inspector.

(*b*). Three engineer commands of fortresses (Antwerp, Liege, Namur) on whom depend the engineer commands of sectors of those places.

(*c*). A regiment of four battalions and a depôt. The battalions have each four companies, and of these the first is a field company, and the remaining three are fortress companies. These three companies are assigned to Antwerp.

(*d*). One fortress battalion at Liege, and another at Namur, each with two active and two reserve companies.

(*e*). Five special companies, these are, one telegraphist, one miner and artificer, one railway company, one pontooneers, and one workmen and aerostats.

Mitrailleuses drawn by Dogs.—*La France Militaire* of the 28th August mentions that trials on a large scale are being made in Belgium for drawing mitrailleuses by means of dogs. The arm is carried on a small carriage of 0·80 m. in height, drawn by two dogs. In the event of it not being possible to use dogs, two men can carry it ; one carrying the mitrailleuse, and the other the carriage. In the trials

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that were made, four men were able to carry the mitrailleuse over a wall 3 m. in height in 40 seconds. The transport by dogs is regular and rapid, and has the advantage of being less visible at a distance. The authorities reckon upon being able to bring the mitrailleuse by this means up to the line of fire.

GERMANY.

Peace Strength of the German Army.—From the *Internationale Revue über die gesamten Armeen und Flotten* of September we learn that, by the law of 3rd July, the complete strength of the German Army on a peace footing is stated to be between 544,211 and 661,478 men. The number of field and horse batteries remains at 633. The batteries of full strength, in number 255, are composed each of 4 officers, 143 N.C.O.'s and gunners, 75 horses, 6 guns, 6 ammunition wagons, and an observatory car with a pair of horses. The 345 batteries on the reduced scale have each 4 officers, 124 N.C.O.'s and gunners, 75 horses, 6 guns, 6 ammunition wagons, and an observatory car with two horses. The 33 horse batteries have each 4 officers, 137 N.C.O.'s and gunners, 144 horses, 4 guns, 4 ammunition wagons, and 1 observatory car.

Dirigible Destroyed.—It is reported in the *Technique aéoranautique* of 15th August that the German dirigible S.L. 1 (Schütte Lanz) (2) has been destroyed in a violent storm that forced it from its anchorage in the place of arms of Schneidemühl. This airship was of the rigid type, and had a capacity of 19,500 cubic metres, a length of 131 metres, two cars, two motors of 270 h.p., and two steel propellers. Its average velocity was 65 k.m. an hour.

The German aerial fleet met with another serious disaster a short time after; the dirigible L.1 belonging to the marine service was completely destroyed in the first days of September, by falling into the sea, and causing the death of some of the crew. The L.1 of the Zeppelin type had a capacity of 22,000 cubic metres, a length of 160 metres, three motors of 510 h.p., and could attain a velocity of 83 k.m. in the hour.

Bomb Throwing from Aeroplanes.—The *Lega navale* of the 31st August reports that trials were made at Kiel of throwing bombs from a height against the old ship *Bayern* which served as a target. The bombs, of cast iron, were not charged and were thrown from aeroplanes during flight at a minimum height of 500 m. From twelve apparatus, only two bombs struck the target. One struck the stern, the other fell on the forecastle; had they been charged they would only have caused slight damage.

Aeronautical Manœuvres.—According to *La France militaire* of the 26th August, three Zeppelin dirigibles, the dirigible M.4, and fifty aeroplanes will take part in the German manœuvres.

RUSSIA.

In the *Aérophile* of the 15th July, the following notice of military aeronautics in Russia is given:—

Dirigibles.—These airships belong to the types non-rigid and semi-rigid. The more important units are:—*Parseval XVIII.* of 10,000

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cubic metres, 85 m. in length, 15·50 m. diameter. It has two motors with six cylinders of a total of 300 h.p. and can attain a velocity of 72 k.m. an hour. *Clement Bayard VII.* of 9,600 cubic metres, 86 m. length, with two motors with four cylinders of 260 h.p. *Griff*, of 9,000 cubic metres, has two motors and a velocity of 65 k.m. an hour. *Albatross* of 9,000 cubic metres. Its two motors give a velocity of 65 to 70 k.m. *Astra XIII.* of 10,000 cubic metres and 77·80 m. of length. Has two motors of 300 h.p. and a velocity of about 60 k.m.

The less important units are:—*Lebedy* (type Lebaudy), semi-rigid, of 3,700 cubic metres and 61 m. length, with two motors each of 70 h.p. *Militaire P.L. VII.* (Parseval), non-rigid, of 6,760 cubic metres, 70 m. length, with two motors of 110 h.p. *Outchebny I. and II.*, non-rigid, of 1,500 and 5,500 cubic metres. *Zodiac VII., VIII. and IX.*, non-rigid, 2,200 cubic metres, length 50 m., with two motors of 110 h.p. *Jastrab*, semi-rigid, 2,800 cubic metres, with two motors of 75 h.p. *Kommissiony* (Clement-Bayard I.), semi-rigid, 3,500 cubic metres, length 56 m., with two motors of 100 h.p., at St. Petersburg. *Forzmann I. and II.*, non-rigid, 800 and 600 cubic metres. *Golub* (*Astra*) of 2,270 cubic metres.

It is now stated that the number of dirigibles fit for service is twelve. Russia possesses an office for military aeronautics.

Aeronautic Parks.—Each fortress has a dirigible. These aeronautic parks are stationed at Brest-Litouski, Berditschew, Kiew, Varsavia, Salutschy, Riga, Libau, Petersberg, Sveaborg, Moscow. Attached to each park there are :—one military squadron, some autocars, and sections of kites and spherical balloons.

Aeroplanes.—The biplane is adopted for service in the forts and the monoplane for field service.

All the fortresses are provided with apparatus, pilots, squadrons of aviators, depôts for combustibles, and automobiles. The field squadrons are placed at the disposition of the troops, and each army corps has two ; altogether there are 60 squadrilla each with six monoplanes.

In Russia there are ten military aviation centres with aerodromes at Petersberg, Gatschina, Moscow, Kiew, Charkow, Odessa, Saratow, Riga, Varsavia, Sebastopol. Two other centres are being formed at Omsk and Tachkend. There are aeronautic schools at Petersberg, Wolkova-Pole, Gatschina, Kiew, Chackow, Varsovia, Odessa, Riga, Saratov, Sebastopol, the most important being the last owing to favourable climatic conditions.

Hydroplanes.—There are two principal stations for hydro-aviation, one at Sebastopol, and one being formed at an island near Petersberg.

Pilots.—The Russian Army now has 150 brevetted pilots for aeroplanes, in addition to 190 other pilots from the *Aero-club Imperiale*. There are six sections at Petersberg, Moscow, Riga, Odessa, Saratow and Charkoff, each of which place has a school.

E. T. THACKERAY.

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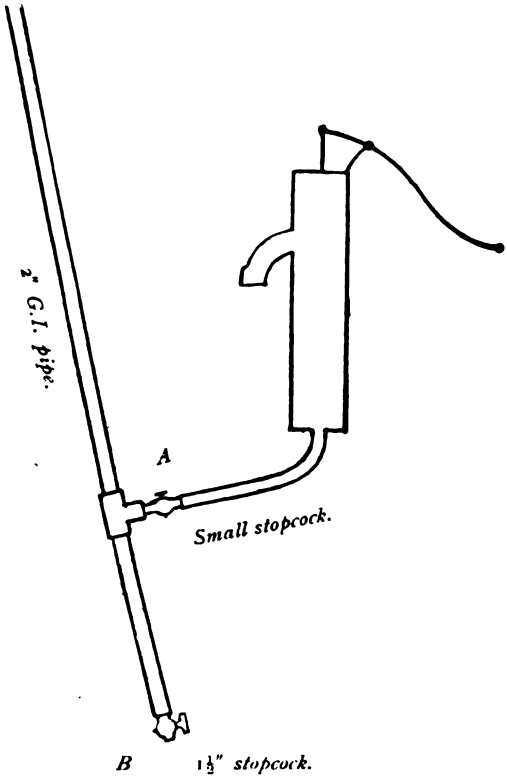
CORRESPONDENCE.

THE SIPHON AS AN AID TO WATER SUPPLY.

DEAR SIR,

With reference to the article on Siphons at Sierra Leone by Capt. Mahon in last month's issue, I find *Plate* I. and its instructions a little difficult to follow owing to two of the 2-in. stopcocks having the same number (viz. No. 2).



INSTRUCTIONS.

Open **A**, close B, and pump.
When pump delivers close A, open B.

I wished recently to siphon out a 6,000-gallon tank, using 120 ft. of ¾-in. garden hose and a small tripod barrel pump. I found the end of

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the hose, which was slightly tapered, just fitted into the suction hose of the pump. I daubed the joint with clay, and pumped; as soon as the pump began to deliver I broke the clay joint, and the siphon ran for many hours before it stopped, when a short turn at the pump started it again.

I wonder whether a slight modification of this would not have worked through 530 ft. at Sierra Leone. It seems to me that a pump near the junction with 4-in. main, arranged as in sketch, should suffice, but perhaps an ordinary pump would not work through such a length of 2-in. pipe. If it did there would be a saving of several 2-in. stop-cocks.

H.K.

13th January, 1914.

The Editor, *R.E. Journal.*

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RECENT PUBLICATIONS OF MILITARY INTEREST.

REVIEW OF BOOKS.

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BIOGRAPHY AND HISTORY.

NAPOLEON IN THE FIELD. (Napoléon en Campagne). By Colonel Vachée. 215 pp., with 3 maps to illustrate the Jena Campaign. 8vo. Paris, 1913. Berger Levrault.

This is a very interesting book and well worth reading. The object of the author is to present Napoleon to the reader "living, thinking and acting at his Headquarters, with his passions and his habits, his voice and his physiognomy, just as he might appear to a staff officer who has just taken part in a campaign under the Emperor's orders." And most readers of this book will agree that the author's object has been successfully attained.

Chapter I. deals with Napoleon's methods of considering and deciding on his plan of action, and the author quotes numerous authorities to show that in making his plans the Emperor consulted no one, and that every order which emanated from Imperial Headquarters was dictated verbatim by Napoleon himself. Officers of his Staff expressed astonishment at the rapidity with which Napoleon dictated his orders and answered all questions put to him regarding them. To these Napoleon replied: "If I appear always ready to answer any question, it is because, before undertaking any enterprise, I have long pondered over it and have foreseen what may happen. It is not a flash of genius which tells me suddenly what to do or say when something unexpected by others happens; it is by dint of deep thought that I have been able to anticipate the apparently unexpected." Colonel Vachée remarks that this habit of constantly looking ahead and working out his plans a long time in advance was one of the principal causes of Napoleon's astonishing successes. Another very valuable asset possessed by Napoleon was that he could work just as easily by night as by day. "This extraordinary man was so constituted that he could sleep for an hour, wake up and dictate an order, go to sleep again and be roused at intervals during the night, without his health suffering in any way. He only required six hours' sleep in twenty-four and it made no difference to him whether he had these six hours straight on end or at intervals." On the eve of a battle Napoleon made a practice of spending the night in thinking over his plans. He usually lay down after dinner about 8 p.m., but got up as soon as the reconnaissance reports came in, usually about midnight. On a large table in the middle of the room surrounded by 20 or 30 candles, was spread a map of the theatre of war, on which was shown, by means of pins with differently coloured tops, the positions of his own troops and those of the enemy as far as known. Walking round the table with a pair of dividers in his hand, the Emperor decided on his plan of action and afterwards dictated his orders, which were carried out by the troops in the early hours of the day.

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The author points out the advantages of this system of night work, but he rightly remarks that it involves a great strain and cannot be carried on indefinitely, and in this connection quotes Napoleon himself as saying in 1805: "I shall be fit to wage war for another six years, after which I must stop."

As Napoleon anticipated, after 1809 his powers began to decline, his ideas began to lack clearness and precision, his character appeared to lose some of its firmness and his marshals remarked that he began to think more of his personal comfort than heretofore.

In Chapter II. it is pointed out that as soon as Napoleon had decided on his plan he at once dictated the orders for giving effect to this plan. He moreover insisted on his marshals adopting similar methods when they received orders from him. Several samples are quoted of marshals being reprimanded for dilatoriness in issuing orders. For instance, on November 26th, 1814, Napoleon writes to Augereau: "My cousin, what! Six hours after receiving the first troops from Spain you had not started. . . . If you are still the Augereau of Castiglione retain your command, but if your sixty years are weighing heavily on you, hand over to the next senior officer." Commenting on Napoleon's practice of dictating all his orders without consulting his Staff the author says that it resulted in a great saving of time, but he admits that "this method of command should not be taken as a model."

Chapter III. is a particularly interesting one and describes the opening phases of the Jena Campaign, with a detailed account of what passed at Napoleon's Headquarters during the historic night, October 11th—12th, 1806, when the plans were made and orders issued which led to the victories of Jena and Auerstadt. An examination of the orders issued to the various French marshals shows that each was merely told where his corps was to march to, and the position of the rest of the Army, whilst, in the case of the corps in the front line, instructions were added as to obtaining news of the enemy. Not a word was said as to information about the enemy, what the general plan of the Emperor was or what part each corps was to play in it; nor was any mention made as to the zones of march assigned to each corps. No attempt was in fact made to issue a combined order as laid down in our *Field Service Regulations*. The absence of such orders led to great inconvenience and nearly to disaster.

Chapter IV. contains an entertaining account of the *personnel* of the Imperial Headquarters, which consisted of two entirely distinct parts—namely, the Emperor's Military Household and the Staff. The Military Household consisted of Napoleon's immediate entourage, which, we are told, numbered on December 21st, 1806, some 800 persons. The three prominent personages in the household were Berthier, Chief of the Staff, Duroc, the Grand Marshal, and Caulaincourt, the Grand Equerry. The author describes in detail the personal characteristics and duties of these superior officials as well as those of lesser lights such as Bourrienne, Meneval, Fain and Bacler d'Albe. The description of Berthier is hardly flattering. He is said to have been "small, fat, always laughing, very busy in love with Madame Visconti," and again he was "badly built, with a head too large for his body, naturally ugly hands, which were made to look even more repulsive owing to his habit of continually biting his nails till his fingers bled." Colonel Vachée gives also a vivid description of life at Imperial Headquarters, where "the atmosphere was very agitated and everyone remained constantly on the *qui vive*." Often when his hard-worked Staff had lain down for an hour's badly-needed sleep the Emperor would say, "Wake up everybody and order the horses." We are told that Napoleon liked this system because it kept everyone "up to the mark."

When the enemy was at a distance Napoleon always drove in a carriage, but when fighting was imminent he invariably rode, until the year 1809, after which he began to put on flesh and rode less, until finally in 1812 he rarely quitted his carriage. When on horseback he was followed at a short distance by Berthier and the Grand Equerry, the latter carrying a map of the country "attached to a button of his coat." Close behind these two came a page carrying a telescope and further behind again numerous orderly officers, aides-de-camp and the Emperor's personal escort. Apart from Napoleon's Military Household, the remainder of the Imperial Headquarters

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consisted, as mentioned above, of the Staff. The latter were practically Berthier's staff, and had comparatively little to do with Napoleon. They formed, in fact, as one of Napoleon's secretaries once said, "a world apart." Berthier, who endeavoured in every way possible to imitate his master, divided his staff in very much the same way as Napoleon did, having a small "cabinet" of specially trusted officers as distinct from the remainder of the staff. Colonel Vachée details the duties of the various branches of Berthier's staff at some length, and compares the *rôle* of the latter with that of the German Staff in 1870. The scope of the French Staff in Napoleon's day was so restricted that it really was not a staff at all according to the modern acceptance of the term. As the author remarks, "it is certain that the Staff was a weak point in the armies of the First Empire, and that the want of a proper Staff contributed to the disasters of Napoleon's later campaigns."

A whole chapter is devoted to showing how Napoleon, having given his orders, took steps to see them carried out. In many instances he personally supervised the execution of his orders, and when this was impossible he sent staff officers out to report whether commanders were carrying out their instructions.

Chapters VII. and VIII. describe Napoleon's methods of dealing with his officers and with the rank and file of his armies, and also the means he employed in order to attach them to himself. We are told: "Napoleon considered that there were only two levers which made any impression on men, namely, fear and self-interest. His great general principle, which he applied in small things as well as great, was that no one could be keen unless he was uneasy in his mind. He therefore never gave anyone his entire confidence, he did his best to incite rivalries and he kept everyone constantly on the *qui vive*."

His two "levers" (fear or self-interest) he applied in accordance with the character of the person with whom he was dealing. In some cases he considered that most effect would be produced by a theatrical outburst of anger, and in others he bestowed money and titles with a lavish hand. Colonel Vachée insists that Napoleon's great aim was to attach his Army to himself personally, and that he placed his own interests before those of France. In corroboration of this he quotes the following passage written by Napoleon to Joseph:—"Don't forget that your first duty is towards me, your second towards France, and your third towards Spain." Again in 1815 after his abdication, he is reported to have said of Davout: "I thought Davout loved me, but he only loved France."

Chapters IX. and X. are particularly well worth reading. In them the movements of Napoleon during the 48 hours preceding the Battle of Jena, as well as during the battle itself, are followed in detail; the information received by Napoleon at various times before and during the battle is placed before the reader, and also the action taken by the Emperor on receipt of the different items of news.

The author then criticizes Napoleon's conduct of the battle in view of the tactical principles laid down by Napoleon himself, and he devotes some pages to considering whether Napoleon was right in placing himself where he did during the Battle of Jena. The conclusion he arrives at is one in which most people will agree, namely, that Napoleon's position on the Dornberg was too near the fighting line, and that owing to his being there he became absorbed in the operations which were taking place in his immediate vicinity between the Landgrafenberg and the Capellendorf, and consequently somewhat lost control of the battle as a whole.

The book concludes with an interesting comparison of Napoleon's method of commanding in the field and that adopted by the Headquarters of the German armies in 1870. The proceedings of Napoleon at Auma on the night of October 11th—12th, 1806, are contrasted with those of the German Headquarters on the night of August 6th—7th, 1870. The point on which the author lays particular stress is that Napoleon on receipt of important information consulted no one before issuing his orders, and consequently a great deal of precious time was saved; whereas with the Germans in similar circumstances five or six people had to be roused and consulted before the necessary orders could be drafted. Colonel Vachée expresses preference for the Napoleonic system of command, but seems rather to lose sight of the fact that such a system requires a Napoleon to carry it out.

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THE WAR OF 1870-71. THE 1ST ARMY OF THE LOIRE. VOL. I. TOURY-EPERNON. (La Guerre de 1870-71. La 1_{ere} Armée de la Loire I. Toury-Epernon). 282 pp., and documents annexed, 238 pp., with 18 maps. 8vo. Paris, 1913. Librarie Chapelot. 11s. 3d.

This volume is produced by the Historical Section of the French General Staff, and its accuracy may therefore be considered unimpeachable. It is obvious from the great number of documents (both French and German) referred to, and in many cases reproduced verbatim, that no pains have been spared to obtain a true and impartial story of this period of the Franco-German War.

The reader will, however, be considerably disappointed to find that this volume is, to a great extent, simply a narrative of events and that it is almost devoid of comments. Practically the only thing in the nature of comment appears on pp. 94, 146 and 162—168, where it is pointed out that the want of success attending the operations of the newly-formed XVth Army Corps was to some extent due to the absence of any unity of control over the operations carried on in the neighbourhood of Orleans during the latter part of September, 1870.

The volume is divided into six chapters of narrative and six chapters of appendices. In the latter many of the documents forming the basis of the narrative of operations are quoted at length.

Chapter I. describes the origin of the Army of the Loire, and the manner in which the various units forming the XVth Army Corps were raised. Chapter II. gives the situation of the German forces in the south of Paris on September 20th, 1870. The movements of General Reyau's cavalry from September 13th and the position of the French forces on the Loire on September 20th are described in Chapter III., whilst a detailed account of the operations round Orleans from September 21st to October 1st will be found in Chapter IV. The following chapter is devoted to the story of the fighting which took place round Orleans between October 2nd and 5th, and includes an account of the engagement of Toury, whilst the final chapter deals at length with the doings of the 2nd, 5th and 6th Prussian Cavalry Divisions from September 21st to October 5th, 1870.

THE JAPANESE IN MANCHURIA. (Les Japonais en Mandchourie). Second Part (The March to Battle) and Third Part (The Battle). By Colonel Cordonnier, French Army. 332 pp., 10 maps, 1 sketch bound in text. 8vo. Paris, 1913. H. Charles-Lavauzelle. 5s.

The First Part of this account (translated into English) was reviewed on p. 596 of *The Army Review* for October, 1912. The book is acknowledged to rank amongst the best contributions to the literature of the war, and merits therefore a full review.

The present volume embraces the Second and Third (last) Parts. The Second Part is headed "The March to Battle." Its first chapter deals with the situation of the IInd Japanese Army and of Stakelberg's Corps on the morrow of Wa-fang-kou. Taking as his text the uncertainty regarding each other's dispositions which prevailed amongst both these forces, the author deals with the futility of historical criticisms by military writers who place themselves "astride of the two camps." For fruitful study we must shut out from our minds, says he, what we know of one side. He instances some judgments passed on former commanders to illustrate his point. In connection with the same situation (Oku's and Stakelberg's) he shows the important *rôle* which cavalry may be called upon to play in modern war.

The second chapter, dealing with communications, contrasts Napoleonic conditions in this respect with existing ones. The Emperor employed no line-of-communication troops properly so called. Reinforcements and invalids passing to and fro in rear had to guard the occasional large convoys. Living on the country was the rule. Reliance was placed largely on penalizing inhabitants for attacks on convoys. To-day communication between front and rear must be safe at all times. The author

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gives figures to show the dominating importance of ammunition supply upon operations. Communication difficulties rather than excessive prudence were responsible for the extreme slowness of the Japanese, whose Ist Army moved from the Yalu to Tawan at an average daily rate of 1,600 yards. Each army, like a ring on a curtain pole, can slip along its line but move only very little from side to side. "It will be thus until mechanical traction frees armies momentarily from the imperious necessity of touch with the railway. On that day . . . communications will lose some of their fragility."

Following on a detailed enumeration of the opposing forces the author (pp. 48, 49) dwells emphatically upon the necessity of controlling "employment" in combatant units. According to the Russian General Martynov (quoted by him), one Russian infantry regiment (four battalions) had 1,800 employed men to 2,600 in the fighting line.

The final chapter of the first half of the Second Part headed "Accept or refuse battle?" analyzes the situation on the eve of Liao-Yang, and the action of the Russian Commander-in-Chief.

The second portion of Part II.: "Liao-yang, the fighting during the approach (to that battlefield)," begins with a consideration of strategic envelopment. With armies of the size seen in 1870 and 1904, says the author, this envelopment must be prepared long beforehand. To study this question consult the writings (conceptions) of great commanders rather than events where "the action of obstinate and often incapable subordinates has at times been felt." Again: "The Power which disposes of the largest forces will take up the space necessary for their deployment *wherever this space is to be found and can easily be occupied, either in its own territory or in that of a neutral too indifferently armed to ensure respect for his neutrality.*" (Italics are the author's).

Next follows a chapter on the strategy of interior lines with reference to the situation of the contending armies before Liao-yang. It is abundantly illustrated by historical examples, especially from the Rivoli Campaign. The author then discusses the approach of the Japanese armies on Liao-yang: "To remain out of range, each facing his objective, and then to fall upon the enemy all together—such is the theory of movements leading to envelopment." Commendation is lavished on Kuroki's bold tactics on August 25th and following days in engaging on a broad front and with practically no reserves the Russian Eastern Detachment; and his subordinate, the commander of the Guard Division, is similarly praised for his action against the IIIrd Siberian Corps.

On p. 114, after referring to a panic which broke out on August 26th in a Russian battery on the left of the force opposing Kuroki, the author says: "With artillery, panics begin amongst the wagons . . . panic is the most contagious of an army's maladies . . . a firm hand is required to preserve order amongst this mass (of vehicles and teams); now everyone capable of commanding is in the firing line . . . no highly-qualified commanders exist amongst the bunches of wagons." Reading this we may congratulate ourselves on having an officer detailed to the wagon line.

Commenting on the same fighting the author describes the interruption of telephonic communication between the general officer commanding the Xth Russian Army Corps and his subordinates, and draws the conclusion that undue reliance must not be placed upon mechanical means: "In war the true communication is a tactical idea well expressed to well-trained troops." He cites the success of the 46th Japanese Regiment on Kuroki's right on August 26th as an instance of the far-reaching effects which the fight of a small fraction of an army may bring about. In this case it contributed to the retreat of the whole Russian Eastern Detachment behind the Tan-ho.

In Part III. the author first portrays the Japanese situation as follows:—The junction of the armies, the strategic enveloping manœuvre, is effected; but great uncertainty exists as to the enemy. He quotes rather equivocal orders given by Napoleon—when in a similar state of uncertainty—to Soult on November 10th, 1808, to illustrate difficulties of command. Napoleon's object always was, says the

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author, to produce *la bataille à fronts renversés* (each belligerent facing his base). Thus alone can decisive results be attained. In Europe it may again become practicable to fight in this posture if the commander of an army has the audacity required. This audacity depends on knowledge of the adversary's fighting value. Napoleon knew this value through constant fighting. To-day it is unfathomable—after a long peace. Early engagements of a war will, however, reveal it. Hence their comparative importance.

Succeeding chapters discuss the Japanese orders for the battle and the linear nature of their attack. The author approves of the tactical dispositions made under the circumstances existing. For an army corps and lesser forces, says he, reserves are essential; but their value decreases proportionately to the increasing size of units larger than the army corps. Time and space limitations will generally result in army reserves being unemployed. Instead, says he, vary the density of front of the several attacking bodies according to the tasks allotted to each. Dealing with the defensive he criticizes Kuropatkin's "intention" paragraph, and his massed army reserves (two and a-half army corps) which should have been more elastically disposed (*articulé*). The inaction of Mishchenko's cavalry comes in for severe censure. "Cossacks are mediocre cavalry soldiers; their mounts are paltry little animals; their military training is practically *nil*." Yet, continues the author, since this war a *néfaste* taste for dismounted action has sprung up. He reproaches the German cavalry especially with having lost the "go" imparted by Ziethen and Seydlitz, and with preferring the rifle to the lance.

Commenting on the paragraph of orders directing each army corps to send two officers to Kuropatkin's Headquarters, he expresses disapproval of the *officiers de liaison* system as practised in France also. "These officers," says he, "bring with them the mentality from below." "*Il faut donc fortement constituer les quartiers généraux, et habituer chacun à se suffire avec les résources qui lui sont attribuées.*" On the other hand he commends the Russian practice of inserting in orders names of officers to succeed the Commander-in-Chief if the latter becomes a casualty. "We French, who have reason to remember what happened at Sedan after MacMahon was wounded," says he, "should never omit this precaution."

A series of chapters headed "The Battle. Combats within the Battle," opens with an interesting study of the size of strategic units. The author comments on the interchangeability of Japanese divisions, each being homogeneous and one-thirteenth of the whole Army. Moltke's army corps corresponded to both these conditions. Napoleon I. formed army corps when a division no longer totalled one-twentieth of the army of which it formed part. Accordingly, says the author, the great military powers of to-day require permanent units of 100,000.

The chapter entitled "*Manœuvrer l'ennemi par le combat*" contains an interesting study of advanced posts, and co-operation between infantry and artillery, as illustrated by the action of Lieut.-Colonel Pokotilo's 3rd Battery of the 6th East Siberian Rifle Division in order to extricate the IIIrd—23rd East Siberian Rifle Regiment. He considers that on the night of August 30th—31st the Russians should have moved a complete army corps (the IVth) on Liuntai to roll up the Japanese left, but adds that such a difficult movement could only be carried out by troops well trained during peace time in movements by night.

The fighting along the front of the Japanese IInd Army on August 30th and 31st supplies him with many examples of illustrating the employment of artillery. He emphasizes the oft-repeated view that the worse the infantry the greater need for guns. He considers that the Japanese artillery did not give its infantry as much support as it might have. He is a firm believer in the necessity of artillery following up an infantry advance. What, he asks, does the infantry soldier understand of the disadvantages of interrupting fire and ranging afresh? He is a "big child" on such occasions. If the artillery remain behind he thinks they are afraid. The author has high praise for both infantries, and thinks especial credit is due to the Russian, weighed down in *moral* by previous defeats. He infers a doubt as to whether western European countries will produce foot-soldiers of equal merit to either. Which will be better, he goes on to say, French or German? All depends upon

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infantry. Hesitation caused by doubts as to relative values of this arm is, he adds, the surest guarantee of peace.

The earlier of a series of chapters entitled "*La décision dans la bataille*" is devoted to a eulogy of Kuroki's bold tactics in crossing the Tai-tzu-ho; and to criticisms on the Russian higher leading which ordered a general retreat on the strength of premature and inaccurate cavalry reports as to a Japanese crossing in force over the river.

Then follows perhaps the most remarkable chapter of the book. Under the title "The division of labour," the author considers the *rôle* of all from the chief, whose importance declines from the moment battle is joined, to the private who reigns supreme at the end, and becomes the arbiter of the country's destinies. "The colonel and other officers will one by one be absorbed into the fighting line; . . . no longer commanders, but splendid soldiers to whom fear is unknown. In order to triumph it will only remain (for the officer) to let him (the private) act, or better still to make himself into a private too." How does this compare with the homilies read to British officers in South Africa, who were upbraided for exposing themselves inasmuch as they were too "valuable."

Colonel Cordonnier concludes his masterly study by a *précis* of later events in the war, and a comparison between the Manchurian Campaign and that of 1812 in Russia, in which one army likewise retired continuously before the other. In his final reflections he connects policy, peace preparations, strategy and tactics; and shows how insufficiency of efforts at peace preparation increases proportionately the efforts required during the actual struggle, and *vice versâ*.

The author's vivid style and imposing knowledge of military history combine to render his book a most valuable treatise not only on this particular campaign but on war generally.

There are some obvious misprints:—On page 166, I (d), "XVIII." should read "XVII." Page 250, sixth paragraph, first line, "IVth" should read "Xth" (Corps). In the penultimate line of the penultimate paragraph of p. 280 "IIIrd" should read "IVth" (Army).

MY COMMAND IN THE BALKAN WAR, 1912. (Meine Führung im Balkankriege, 1912). By Mahmud Mukhtar Pasha, commanding the Eastern Army. 190 pp,. with 1 photo and 7 maps. 8vo. Berlin, 1913. Mittler. 4s.

This very interesting book affords a detailed and vivid picture of the operations in Thrace from the outbreak of the war to the Chatalja *impasse*. Included in the text is an extensive series of operation orders, messages, and reports, which show that the Turkish leaders were at any rate inspired by the will to assume the offensive, if they lacked the qualities necessary to carry it out.

Mahmud Mukhtar records in detail the terrible deficiencies in organization and training to which he ascribes the collapse of the Turkish Army. Among other things it appears that the only information which the Turks obtained about the Bulgarian movements was derived from the Austrian newspapers.

As Mahmud Mukhtar admits, the Turkish Army was beaten before ever the Bulgarians attacked.

STRATEGY, TACTICS AND TRAINING.

NOTES ON FORTRESS WARFARE. (Quelques Idées sur la Guerre de Place). By Colonel Rouquerol. 56 pp. 8vo. Paris, 1912. Chapelot. 10d.

The well-known artillery officer, Colonel Rouquerol, has written a small pamphlet on fortress warfare, which is worthy of perusal if only for its lucidity of expression and close reasoning. In a short preface, the author shows that the introduction of explosive shells cannot, as some people have suggested, make fortifications useless. The fundamental principles of fortress warfare remain the same, but modern arma-

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ments have rendered anything except permanent fortifications of little use. It is wrong to suppose that field works hastily constructed on the outbreak of war can resist the large calibre howitzers, etc., which modern armies carry in their siege trains. Only permanent works of concrete and steel will avail, and they must be carefully planned and constructed in times of peace. Fortresses of obsolete types should not be defended, for they cannot resist more than twenty-four hours against heavy artillery.

On the other hand, fortresses constructed according to modern ideas will be of the greatest use and will resist for a considerable period. A modern fortress must consist of a line of forts; a line of batteries, which must either be concealed or be made of armour; a secondary line of forts; and, finally, the walls of the town, which, in the author's opinion, still serve a useful purpose. The garrison of such a fortress will, in European warfare, be composed of second line troops, and a small reserve must be kept in hand for the purpose of counter-strokes. There is a short chapter on dirigibles and aeroplanes, which, according to the author, cannot help the artillery but may be of great use in discovering the position of reserves, etc.

THE BRITISH ARMY EXERCISE OF 1913. (Les Grandes Manœuvres Anglaises en 1913). By R. de Thomasson. 33 pp. 8vo. Paris, 1913. Berger-Levrault. 7½d.

M. de Thomasson, who is military correspondent of the *Journal des Débats*, has published in book form his articles in that paper on the recent Army Exercise. His opinion of our Army is, on the whole, most flattering, although he is candid enough to point out some faults and to show where reform is necessary.

In his first chapter he describes for his French readers how the manœuvres of 1912 and 1913 were the final achievement and result of the steady progress made by the British Army since the Transvaal War, and he ventures to hope that the interest aroused by them will lead public opinion to agree to the same military system which all the other Great Powers have had to adopt. He then proceeds to mention the special difficulties with which the military authorities have to contend in arranging manœuvres, and gives a very brief account of the working of the Military Manœuvres Act. This chapter is concluded by a general sketch of our organization (the introduction of the double company system is praised), the programme of the Army Exercise, and the order of battle, in connection with which attention is directed to the high standard reached by our Signal Companies.

Chapter II. opens with the general idea of the Exercise, and describes the marches of the two Brown armies on September 22nd and 23rd. M. de Thomasson, while praising the march discipline of the troops, makes two criticisms: first, that in one of the armies the main body closed up on the advance guard and seemed to be marching without proper precautions, and secondly, that baggage wagons, etc., were placed in between the two divisions. The skill of the cavalry in dismounted action is alluded to, and warm praise is given to the infantry for its thorough training in the principles of the attack. But the general conduct of the fight by the divisional commanders is blamed, mainly because they are apt to rely on a stereotyped distribution, viz., two brigades in first line and one in reserve, and because they invariably divide their artillery among the infantry brigades. M. de Thomasson also makes a remark which is perhaps worthy of consideration. He is inclined to believe that our divisional commanders do not altogether avoid the fault—which he admits is very prevalent in other armies—of "manœuvring too much" and of preferring a complicated flank attack to the simple frontal one. As regards the battle of September 25th, the premature attack of one division and the failure of the enveloping attack are mentioned.

Chapter III. has a most eulogistic description of the British officer, who, it is said, has no superior in Europe. But it must be made clear that the author is referring to the Regular Army, and he concludes this section of the chapter by directing our attention to the necessity of improving the training of the Special Reserve and Territorial officer. One of the points which seem to have struck M. de Thomasson

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is the comradeship existing between officers of different rank. He then passes to the private soldier and describes his uniform and equipment. In his opinion the training of the Army is very thorough—except as regards practice in billeting and the question of food. It is interesting to note that the introduction of cooking wagons is thoroughly disapproved of, on the ground that they burden the columns and will prove useless in war.

The question of the supply of horses is next dealt with, and the artillery teams come in for special praise, although, at the same time, the disadvantages of our field guns are mentioned. The chapter ends with a brief description of our present supply system, which is considered as somewhat " fragile " and capable of improvement by making the supply section of the train carry two days' supplies. The author states that one of the weak points of the British Army is the number of transport wagons required for baggage and supplies, which is, according to him, an old failing. In his final chapter M. de Thomasson discusses the military problem with which Great Britain is confronted. He starts by showing how the Regular Army, the Special Reserve and the Territorial Force are below strength and how various are the remedies proposed for the evil. He does not think that Lord Roberts' agitation has been advantageous, since it has failed to convert public opinion to the idea of universal service while it has discouraged the Territorials and may prevent the prompt despatch of the Expeditionary Force. On the whole he prefers the solution offered by the Duke of Bedford, provided that the authorities guarantee the soldier civil employment on leaving the Army. The idea of Germany attempting, on the outbreak of a great war, to invade this country is scouted, but he also inveighs against those writers who seem to think that the Navy is sufficient for England.

The book can be recommended, for it is not only interesting but useful to read what a competent foreign observer has to say about our Army.

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SOME NOTES ON FIELDWORKS.

THE following notes have been compiled from the fieldwork reports of 1913 and will probably prove of interest. For facility of reference they have been divided into four subheads, viz.: Field Defences, Bridging Expedients, Mining and Demolitions, and Miscellaneous, corresponding to the similar Parts of Military Engineering.

FIELD DEFENCES.

Concealment of Fire Trenches.—A point often lost sight of in commencing a work is that, sooner or later, turf must be cut for concealment of the parapet. It is economical therefore to remove the turf on the area over which the parapet will extend before excavation of the trench is commenced, and assimilation to surrounding ground is improved if the turf is cut in strips of say 15 ft. in length perpendicular to the line of the trench, which are rolled up towards the front and afterwards unrolled in their proper places on the parapet. Although these rolls are apt to break off they unroll again and fit into their places. Care should be taken not to allow the last portion of the roll to break off from the uncut turf (see *Fig.* 1 below).

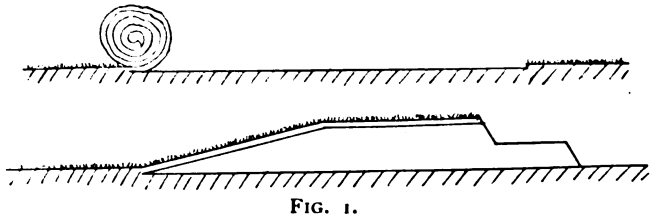

FIG. 1.

Screen during Construction of Trenches.—A screen as shown in the sketch can be conveniently made of latrine screen canvas. The canvas should be daubed with green, blue and red paint and the top of the canvas should be jagged to avoid any sharp line. The screen (*Fig.* 2) appears exactly like a grassy mound and proved invisible at 250 yards even in direct sunlight. Behind such a screen men in exposed positions can work unseen by any but aerial observers.

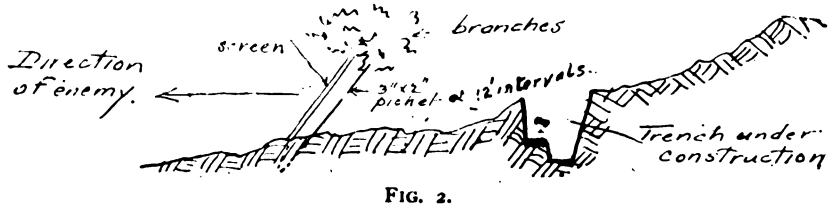

FIG. 2.

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Loophole Screens.—Loophole screens as in *M.F.E.*, *Plate* 11. *Fig.* 2, with sandbag canvas daubed with green paint instead of turf as illustrated in the plate were found less clumsy and just as effective.

Clearance of Foreground.—An old and strongly-rooted hedgerow of white thorn, and bank, 65 yards long, and mean section 8 ft. by 2 ft. 6 in. by 2 ft. at top, to be removed from rifle range.

The hedge was removed and collected for firewood, and the earth scattered. The work was given as a task, and actually occupied 76 man-hours. Rate per man-hour $\frac{8}{10}$ yard-run.

Forest Devil.—A contrivance used by woodmen for pulling down trees is known as a " forest devil," and might easily be improvised and be useful. The principle of it will be clearly seen by reference to *Fig.* 3. It consists of a stout chain secured to the tree to be felled, into the links of which, hooks from two shorter lengths of chain are alternately placed. These short chains are secured to a lever that is worked backwards and forwards, and the tree is gradually pulled over bodily. The lever is anchored back, generally to another tree, and it is estimated that two men can develop a pull of about 80 tons.

Flares and Alarms.—The following points were noticed :—

(1). Flaked dry guncotton intended for priming for flares should be kept away from oil, or it will not ignite.

(2). Ignition is made more certain if a piece of safety fuze is lashed crosswise to the instantaneous fuze within the bag of priming.

(3). Precautions must be taken to prevent cattle being driven over the line of attack to trip wires and set off mines, etc. An ordinary wire fence outside the trips, etc., would prevent this.

(4). A rifle hidden behind a tree trunk was fired by a falling weight when the wire was either tripped over, or cut. In the latter case, a spring was released and dropped the weight (*Fig.* 4).

Smoke Signal.—A " smoke signal " was made, in connection with brigade training, as a signal for a simultaneous daylight attack. The smoke signal consisted of cotton waste, saturated with thick creosote, thin creosote, turpentine and paraffin, in approximately equal quantities. This was carried in a tin, and when required for use the tin was emptied on to the ground and the contents spread out. By stirring the waste with a stick as it was burning, a thick column of black smoke was given off.

Fougasse in Rock.—The 1st fougasse was sunk in rock which had to be blasted out at the bottom. The charge used was 100 lbs. This was fired successfully, but some portions of rock or stone came

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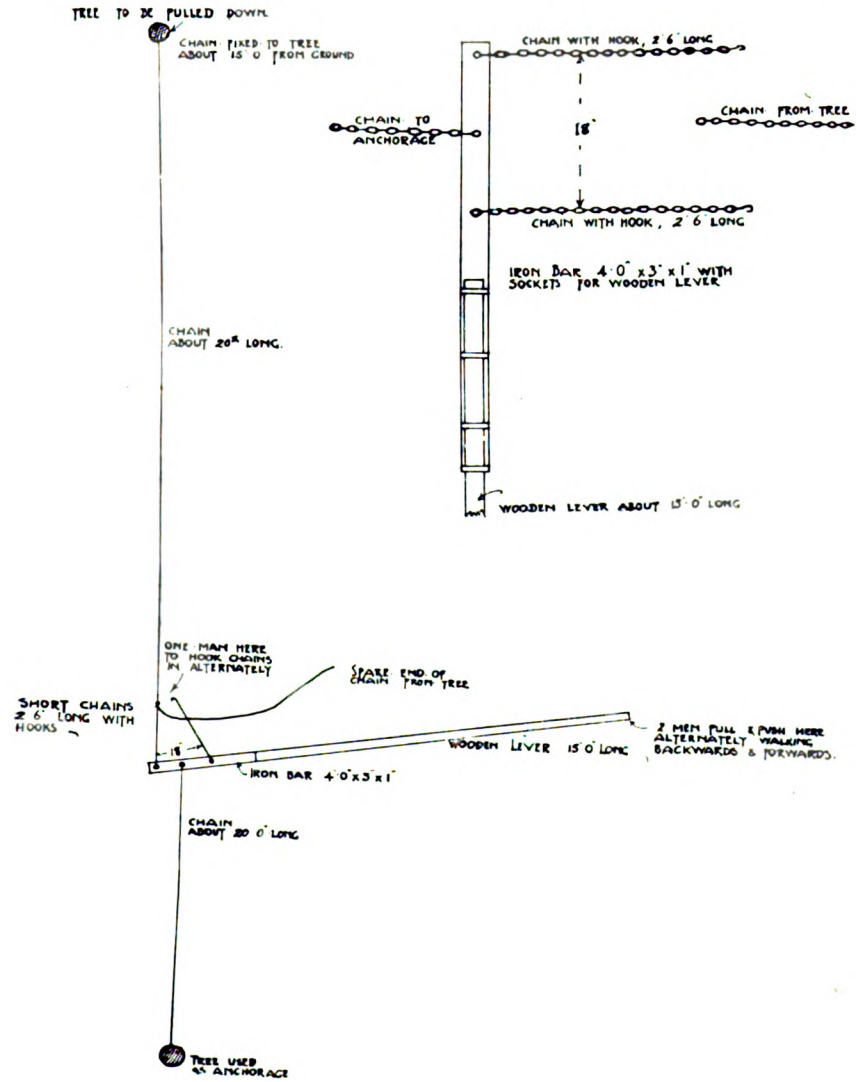
TREE TO BE PULLED DOWN.
CHAIN FIXED TO TREE ABOUT 15'0" FROM GROUND
CHAIN WITH HOOK, 2'6" LONG
CHAIN TO ANCHORAGE
18"
CHAIN FROM TREE
CHAIN WITH HOOK, 2'6" LONG
IRON BAR 4'0" x 3" x 1" WITH SOCKETS FOR WOODEN LEVER
CHAIN ABOUT 20ft LONG.
WOODEN LEVER ABOUT 15'0" LONG
ONE MAN HERE TO HOOK CHAINS IN ALTERNATELY
SPARE END OF CHAIN FROM TREE
SHORT CHAINS 2'6" LONG WITH HOOKS
18"
WOODEN LEVER 15'0" LONG
2 MEN PULL & PUSH HERE ALTERNATELY WALKING BACKWARDS & FORWARDS.
IRON BAR 4'0"x3"x1"
CHAIN ABOUT 20'0" LONG
TREE USED AS ANCHORAGE

FIG. 3.—"*Forest Devil.*"

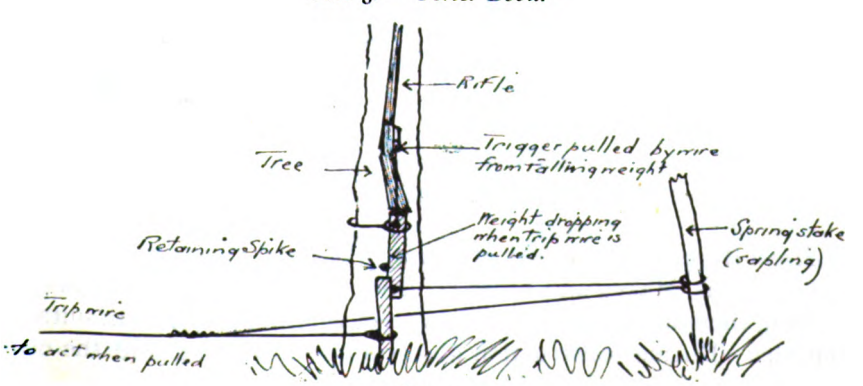

FIG. 4.

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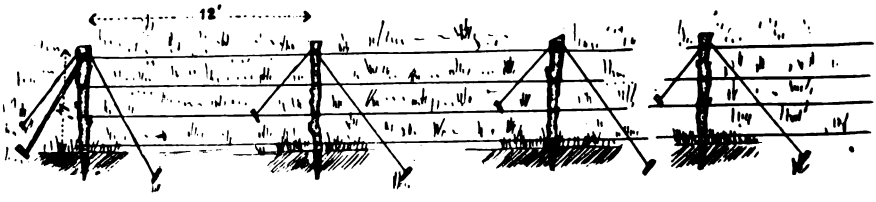
back about 100 yards and went out sideways to the same extent. This was probably due to the fact that the débris from the excavation was put at the back of the fougasse, and to the rock itself being considerably shaken by the blasting which was done in the making of the fougasse.

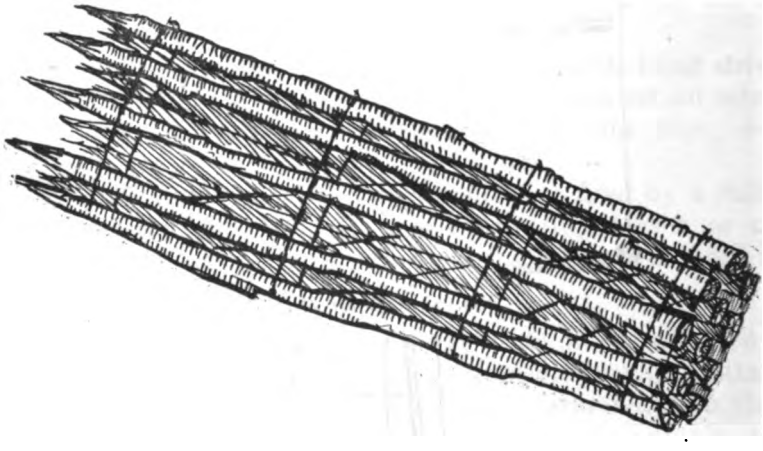
Similar results could be prevented by arranging that nothing but *earth* is put at the back and sides of the fougasse, and, if possible, filled sandbags should be used at the bottom and for the interior slopes of the tamping.

The other two fougasses were dug in earth, except for the last foot which was in the rock. The charge in each was 80 lbs. The above precautions were adopted; the charges were fired electrically, in series, and the result was satisfactory.

Portable Wire Entanglement.—A sketch (*Fig.* 5) is given of this.



Detail. (i.). About 30 yds. to 40 yds. long.
(ii.). Height 4 ft.
(iii.). Distance between posts about 12 ft.



View when rolled up for transport.

FIG. 5.—*Portable Wire Entanglement.*

High Wire Entanglement at Night.—Materials were got ready in the daytime, stakes and brushwood were cut and pointed, pads for driving them in in silence were prepared, wire was re-coiled in suitable lengths. During construction observers were sent out and the only

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thing they noted was the sound of hammering or driving stakes. The following notes may be of value :—

(*a*). Stakes are best not driven into unprepared ground, as heavy driving is necessary. It is better to prepare a hole for their reception with a crowbar.

(*b*). Noise of driving stakes with a maul can be very considerably reduced by pointing the upper ends of the stakes, on which the maul is to impinge. Such points mushroom out under blows, thus forming natural pads for muffling the noise of blows.

(*c*). A more troublesome but more efficacious method for deadening sound is to prepare balls or pads of spun yarn which are held on the tops of stakes while they are being driven.

(*d*). A combination of (*b*) and (*c*) was not tried but may be found the most satisfactory, if at all workable.

(*e*). Pads of empty and folded sandbags and also leather linings to the faces of the mauls were tried but were not satisfactory.

(*f*). Owing to the difficulty of driving long stakes when standing on the ground it is advisable to have boxes on which to stand.

(*g*). It is advisable to have the wire in small coils, but it is necessary to have some simple method of locating the ends of these coils when working in the dark.

(*h*). Hedging gloves are advisable.

(*i*). Caution in handling the barbed wire at night should be impressed upon the men as they are likely otherwise to cause injury to themselves or their neighbours.

Experiments in placing live wires in connection with an entanglement led to the following conclusions :—

(i.). The live wires cannot be incorporated in the entanglement.

(ii.). If placed in front, they would easily be destroyed and might constitute a danger to the defenders' patrols, etc.

(iii.). If placed inside, they fail to protect the entanglement and are dangerous to the defenders.

Bridging Expedients.

Sounding Apparatus.—Made of two chesses crossed and nailed together. A bent nail, in default of pulley,* or if the latter is available use it, and have an eye to guide the sounding line to it,

* A cotton reel makes a very good pulley supported on a nail with a washer on either side.

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carries the sounding line, which must be very light and as non-elastic as possible (see *Fig.* 6).

The pulley must be on the down-stream side so as to not get under the bow wave in a rapid stream.

The amount of line let out at each sounding plus the distance of bottom of plummet from water level when at zero gives the depth.

P.S.—A salmon line makes a suitable sounding line.

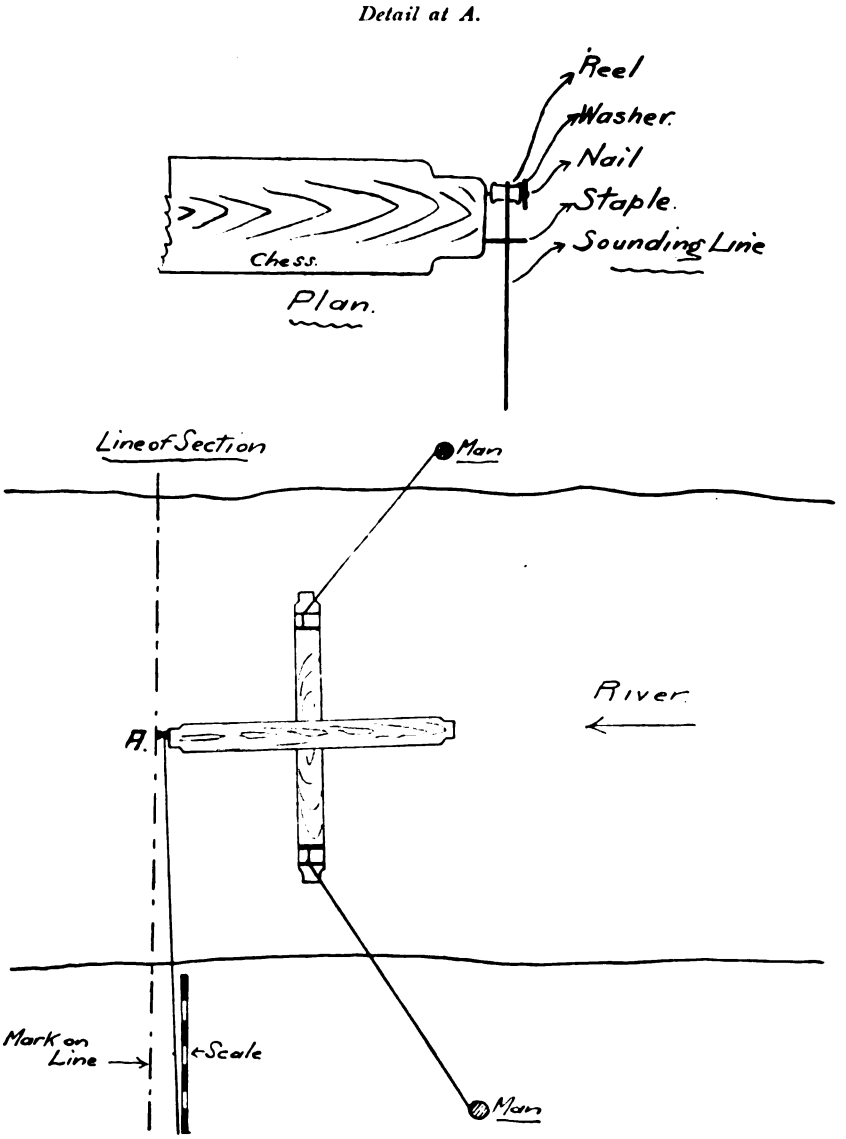

FIG. 6.

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Spiked Trestle.—A type of spiked trestle made of fresh-cut round fir is shown in *Fig.* 7. These trestles proved to be rapid in construction and easy to handle subsequently. The legs were about 6 in.—7 in. butts, and the transom was double, each part about 6-in. diameter resting on half-round chocks let in to the leg, spiked and bound with wire or hoop iron. The transoms were also spiked to the legs, and the two parts secured to one another by small dogs of ¼-in. square iron ; the spikes and dogs were made in a field forge. The ledger was double and spiked to the legs. The diagonals were spiked to the legs and lashed with wire at their crossing. Mud shoes of slats were placed on the bottoms of the legs and also across the bottoms of the ledgers ; 8-in. sinkage was allowed in soft mud, but this allowance proved rather excessive.

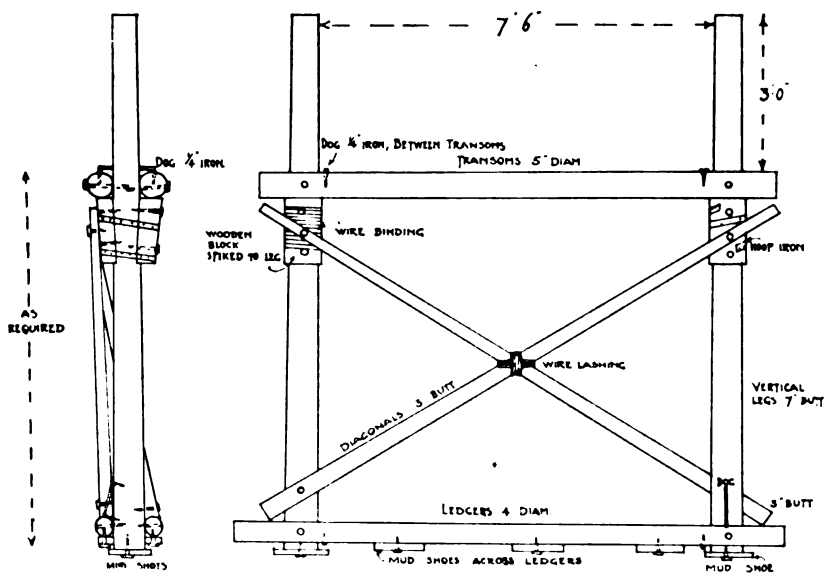

FIG. 7.—*Spiked Trestle of Fresh-Cut Round Fir.*

Launching Trestles.—When the gap to be bridged is not very wide, it was found that a rapid method of placing trestles was to launch them with foot ropes and guys to both banks. This method gives complete control of the trestle, and unless the bottom is very soft, ways are unnecessary.

Floating Footbridge.—A footbridge was made of rushes. These were cut in lengths of about 6 ft. and bound into fascines about a foot in diameter ; these fascines were then made into a continuous roadway by a thin rope in the form of a Malay hitch, and the bridge completed by a central plank to walk on. The bridge was exceedingly steady and stiff.

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Raft of Thames Pleasure Punts, to carry a Limbered Vehicle of 38 *cwts.* (*Double Tool Carts, R.E.*).—The punts to be found on the Thames vary considerably in width, those used were wider than the average but are of a common width (see *Fig.* 8).

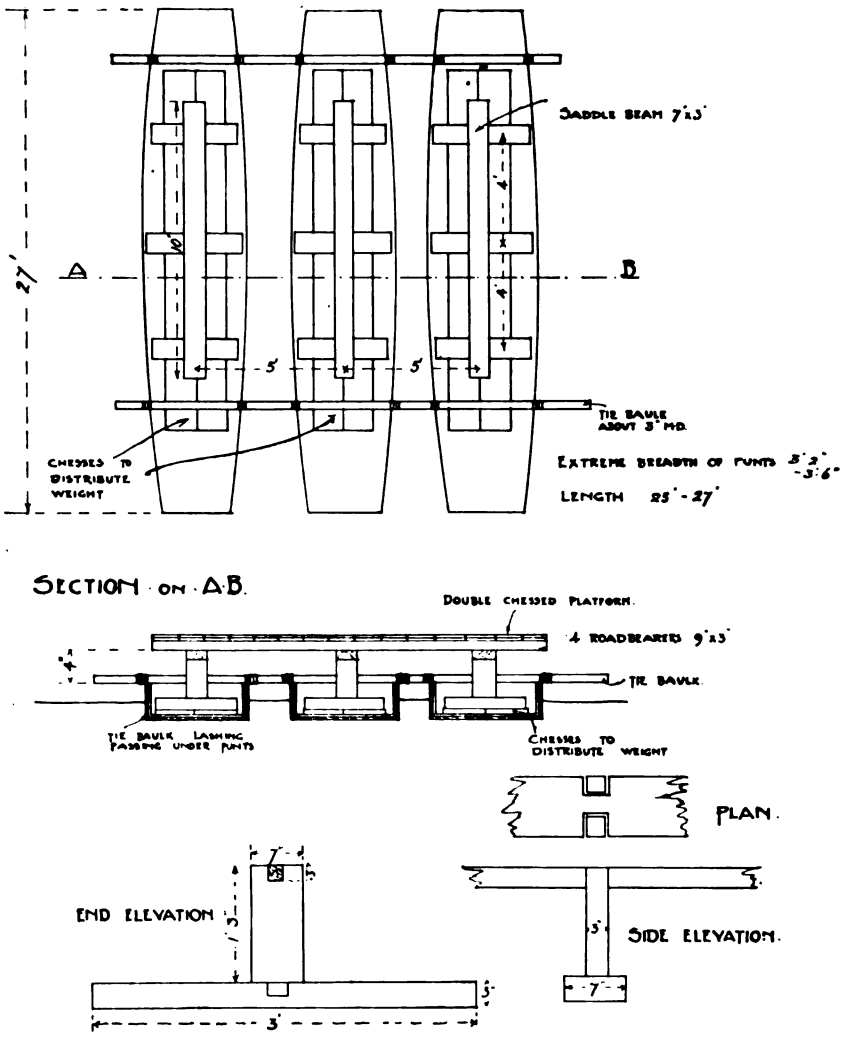

FIG. 8.—*Improvised Raft made of* 3 *Punts to take the Double Tool-Cart* (38 *cwts.*).

The principal difficulty is due to the tendency of the punts to tip over when the load is being brought on to the raft.

To obviate this, end-loading was adopted and proved quite practicable and satisfactory.

The saddles were carried on small trestles and the weight distri-

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buted over the bottom of the punts by means of a couple of chesses.

The scantlings used for saddles and roadbearers were of material which happened to be available, any other scantlings of the required strength would have done as well.

Raft of Double-Scull Rowboats.—A raft of five double-scull rowboats was made to carry a loaded double tool cart, R.E.

A plan of the raft at different stages of completion is given, a cross-section of a boat and a longitudinal section of a boat (*Figs.* 9, 10, 11).

The interval between boats in raft is 6 in.

The raft was formed by booming out, *i.e.* the five roadbearers were lashed to the saddle of one boat and another boat introduced inshore and retained in its proper position whilst the five roadbearers were lashed to its saddle.

The roadway is 10 ft. in the clear.

The raft was loaded with a loaded double tool cart and 16 officers and men and the boats sank till the water was about 7 in. below the top of the gunwale.

No difficulty was experienced in running the tool carts (single) on to the raft owing to the rigidity of the raft.

Combined Bridge Suitable for Unhorsed Vehicles.—A bridge as above was constructed. The width of the river at the point selected was 122 ft. 9 in.

One unit made a raft of four pleasure punts, making a roadway 12 ft. long, and was also responsible for the shore bay, length 9 ft.

A second unit placed in position two trestles, producing 23 ft. of roadway; in addition the Service equipment of the other two units was requisitioned and further roadway was made of five boats of this equipment, to produce 45 ft. of bridge. This unit was responsible for the bay between the 2nd and 3rd unit which was 7 ft. in length.

The third unit made a raft of five double-scull rowboats and produced a roadway of 18 ft. 9 in. This unit was responsible for the bay between the 1st and 3rd unit which was 10 ft. in length.

The last-mentioned raft formed the cut which was worked twice before dismantling.

The bridge was anchored up and down stream.

A difficulty was experienced in attempting to use an odd number of boats (Service equipment) in bridge, owing to the wheelways of one bay being dependent for support on the wheelways of the next bay.

This difficulty was overcome by reducing the length of the outside bay and lashing the wheelways to the saddle of the boats.

A sketch of this bridge is given (*Fig.* 12).

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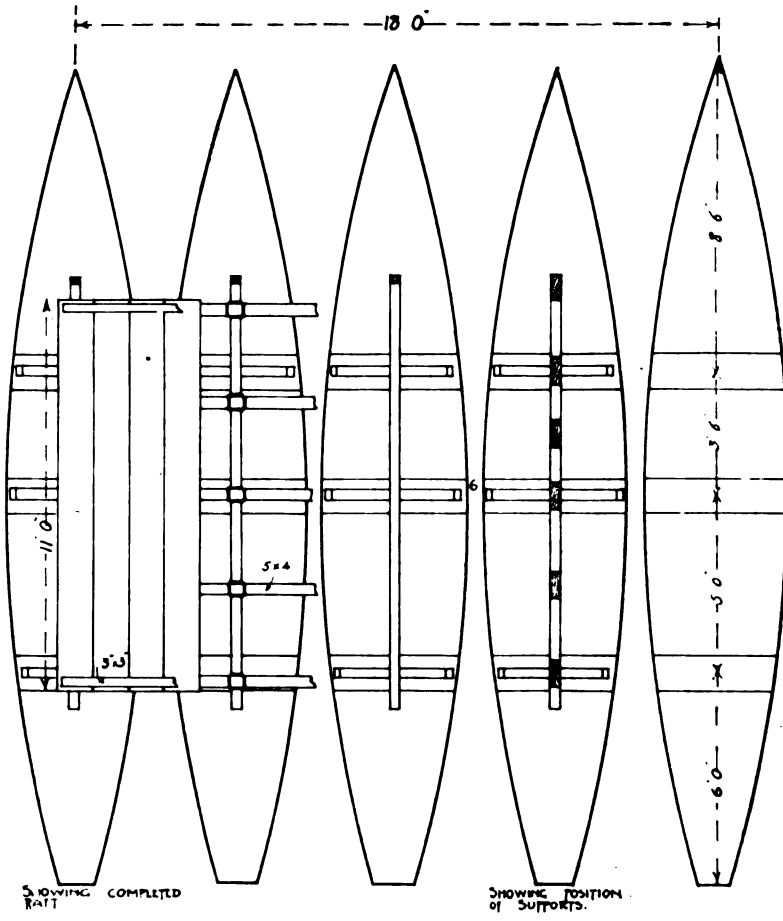
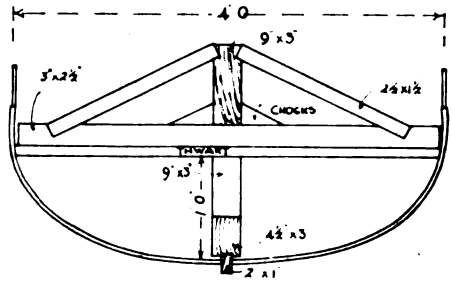
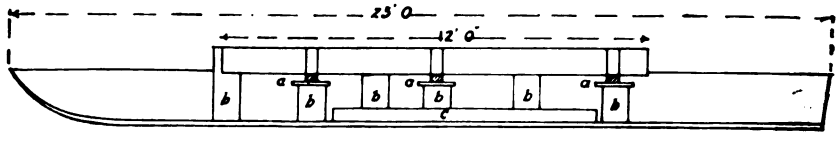


Plan.



Cross Section.



Longitudinal Section.

a. Thwart. *b.* Supports to saddle. *c.* Spar ($4\frac{1}{2}'' \times 3''$) distributing weight on keelson.

FIG. 9.—*Raft of 5 Double-Scull Row-Boats.*

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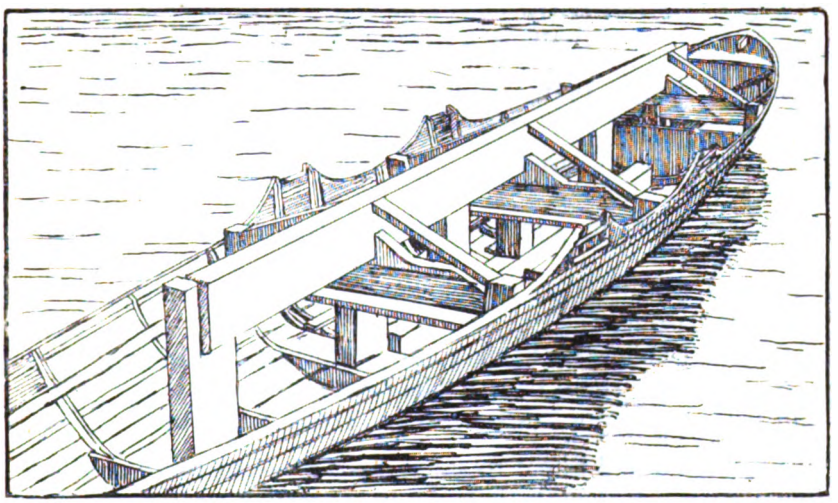

FIG. 10.

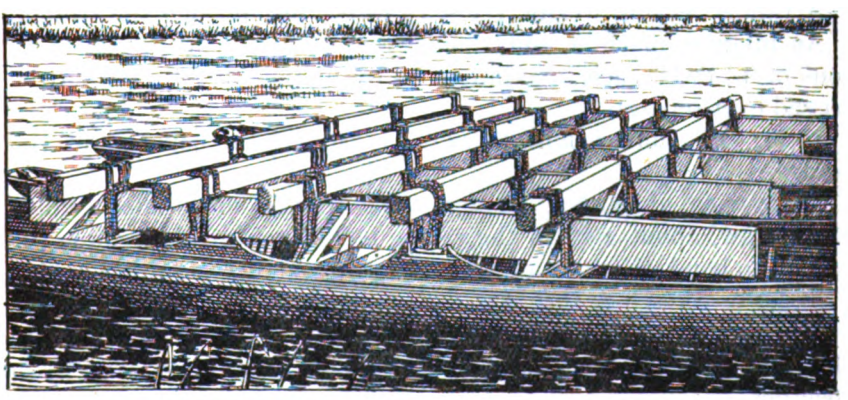

FIG. 11.

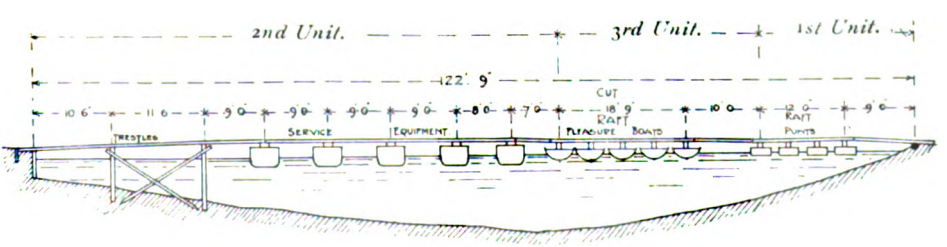

FIG. 12.—*Combined Bridge for Horseless Vehicles.*

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Bridging Expedients to test the Value of Horse Troughs stuffed WITH STRAW *for a Floating Bridge.*

Length of bridge, 45 ft. Time, 2½ hours. 2 N.C.O.'s and 12 men. Stores :—

4 troughs ready laced.
25 chesses.
4 spars, 18 ft. by 3 in. for lashing to troughs and connecting to rafts.
19 spars, 9 ft. by 3 in., for roadbearers and connecting piers.
38 1-in. lashings.
6 1½-in. lashings for hauling out piers when dismantling.
8 pickets for shore bays holding chesses together.
40 trusses of straw, 36 lbs. each. Total, 1,440 lbs.

It was tested and found to safely take a weight of 15 cwts., distributed over 4-ft. lengths it left 2 in. of trough clear of the water as Sketch A (*Fig.* 13).

A G.S. wagon, weight 1 ton, left about ½ in. of trough out of the water.

A timber wagon, weight 1 ton 1½ cwts., just flooded the trough.

An infantry machine gun, double wagon, fully loaded, weighs 1½ tons or 15 cwts. each (maximum) so by unlimbering they could be passed over separately.

18-pr. Q.F. gun, weight 24 cwts., is beyond the capacity of the bridge.

Description of Making Bridge.—The troughs are stuffed tightly with straw, about 2 ft. in the centre is lightly stuffed to allow the trough to bend, the ends are then brought together to form a double cylinder as Sketch A (*Fig.* 13).

The transoms of light spars are lashed over the lace holes, and in three places turns are taken right round the troughs to keep them together.

The piers can now be launched, care being taken to lift them well up to avoid tearing.

Eight roadbearers are lashed across to connect the piers, the two centre ones about 1 ft. apart to take the end of the chesses, the end bearers over the end of the piers and the remainder distributed along between them and fastened by round turns.

The piers are lashed 2 ft. apart, and end roadbearers lashed securely to keep the raft square.

The two rafts are now connected by the transoms and lashed 5 ft. apart, and chessed by placing one row down the centre and two rows each side over the troughs as Sketch B (*Fig.* 13).

The chesses as far as possible are butt jointed and lashed, and are placed parallel to the line of the bridge.

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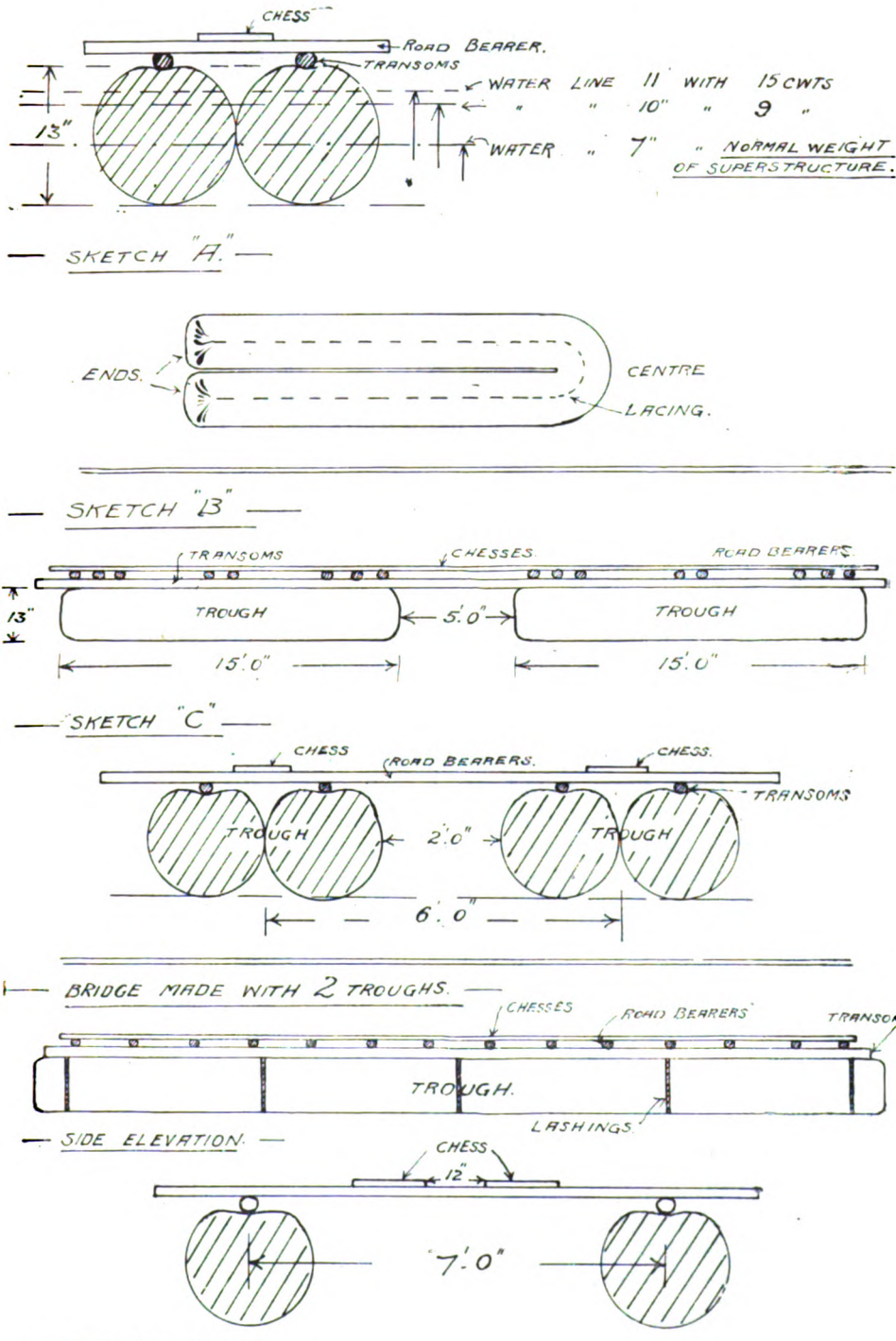

FIG. 13.—*Bridging Expedients.*

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Tests with a Raft made with Four Horse Troughs stuffed with Straw. Roadway, 15 ft. by 9 ft. 6 in. Size of Raft, 15 ft. by 15 ft. Time, 45 minutes.

2 N.C.O.'s and 12 men (6 men stuffing trough ½ hour).
Stores :—

4 troughs (laced).
17 spars, 16 ft. by 3 in.
38 1-in. lashings.
4 1½-in. lashings.
15 planks, 10 ft. × 1½ in.
1,200 lbs. of straw.

It was tested and safely took 38 cwts., consisting of a timber wagon and 17 men, this weight drew 9½ in. of water leaving 5 in. of trough clear of the water.

It would safely take an 18-pr. Q.F. gun=24 cwts. in calm water. The water drawn by the different weights were as follows :—

Height of trough stuffed, 14½ in. ; 9½ in. (38 cwts.) ; 7 in. (26 cwts.) ; 5-in. superstructure.

3½-in. trough stuffed and made into a pier ready to connect into raft.

The rafts were stuffed tightly with straw, about 2 ft. in the centre being only lightly stuffed to allow the trough to be turned into position as Sketch B (*Fig.* 14). Two light transoms are lashed over the trough lacings to keep them rigid and to take the weight evenly, the lashings are taken three times round the trough to keep them together, and round turns taken all down the transoms through the lace holes, the trough is then launched and the four troughs placed close together and the distance pieces lashed over the ends of the transoms, five roadbearers are placed on, chesses laid on and racked down. Owing to the roadway being supported every 2 ft. by the transoms, the roadbearers can be very light.

No spars larger than 3-in. mean need be used.

Bridge made with Two Troughs.

Length, 45 ft. Time, 1½ hours. 2 N.C.O.'s and 6 men.
Stores :—

2 troughs, ready laced.
12 chesses.
17 light spars, about 8 ft. by 3 in.
18 1-in. lashings.
20 trusses of straw, 36 lbs. each. Total, 720 lbs.
8 pickets.

This was tested and 9 cwts. just flooded it.
6 cwts. give 2½ in. out of water.

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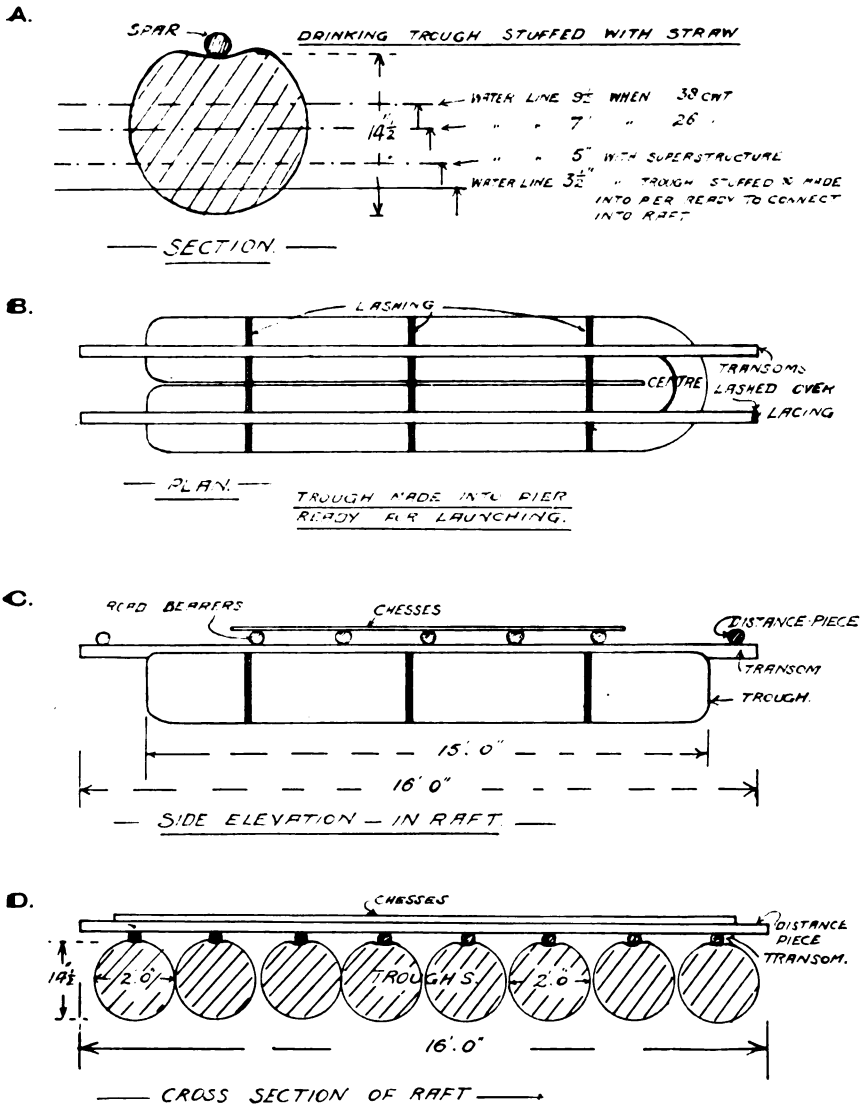

FIG. 14.—*Bridging Expedients.*

Infantry in file gives 2 in. out of water.

The troughs are stuffed tightly with straw and the transoms and roadbearers lashed on and then launched at right angles to the banks and chesses are then placed on and lashed and the shore ends picketed.

A machine-gun wagon empty 5 cwts. could be taken over but the chesses would have to be opened to 5-ft. 3-in. wheel base in centre of chesses.

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Improved Footbridge with Casks.—The following method employed for making piers for footbridge out of single 108-gallon casks was tried and considered an improvement on the ordinary method.

A frame is made, consisting of two long spars, two 5-ft. pickets (or other suitable timber) and one chess and six lashings. No dimensions can be given as they vary with the different sorts of barrel met with, but the distance apart of the long spars should be somewhat less than the diameter of the barrel and they should be slightly splayed. The distance apart of the 5-ft. pickets should be about 1 in. greater than the height of the barrel. The chess is simply a stiffener and keeps the splayed ends of the long spars apart. When the frame is completed the barrel is rolled into the water and the small end of the frame fitted over it, the chess resting in the water. No further lashing is required. The planks of the bridge are then lashed to the frames, and the bridge completed, the weight of the bridge and the buoyancy of the barrel keeping the frame in position.

The advantages claimed for this method are as follows :—

(1). Rapidity of construction.
(2). Ease in launching.
(3). Lashings never slip as they are bound to do however well they are put on if the spars are lashed to the barrel.
(4). Anybody who can tie a knot can make it, whereas it requires much practice and ingenuity to lash two spars to a barrel longitudinally successfully.
(5). Wire can be used for lashings. Wire would be quite useless on the old system as it would not have sufficient grip on the barrel and would be sure to slip off.

For sketch see *Fig.* 15.

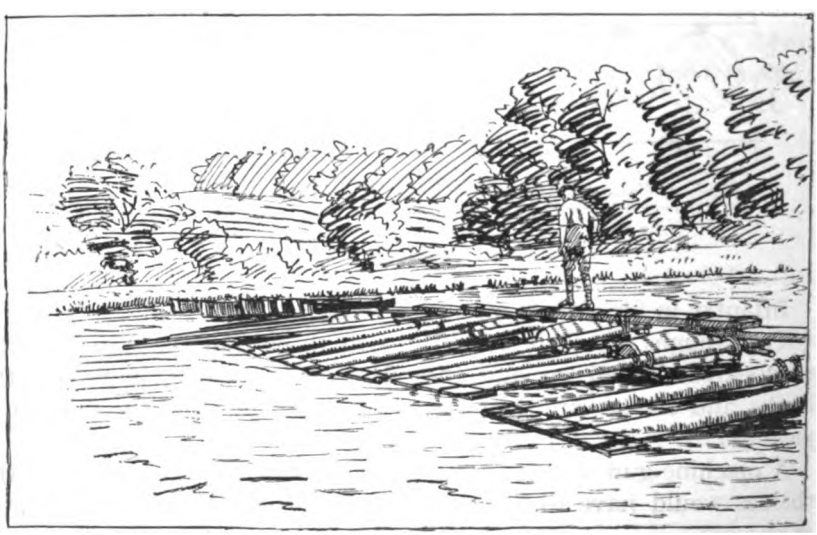

FIG. 15.

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Fig. 16 shows piers made of paraffin tins.

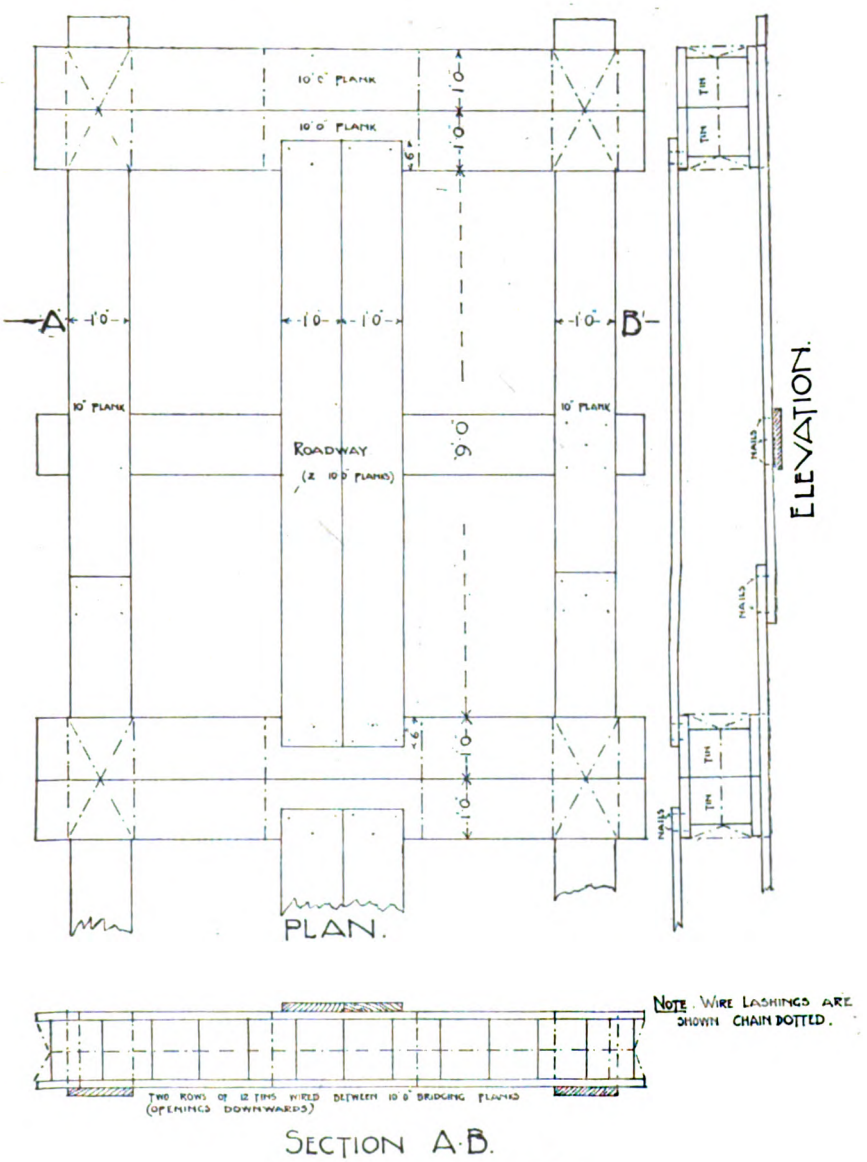

FIG. 16.—*Piers of Paraffin Tins.*

Landing Stage for Boats.—In order to make a landing stage for boats, a framed trestle 30 ft. long was made; this had six legs, pointed at the bottom to drive into the ground. The trestle was put in place, but the ground at the site selected was too hard to allow the trestle legs to be driven, and the whole trestle kept floating up again and eventually broke up. It was then decided to change the

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site of the landing stage to a place where the bottom was muddy. The mud in this new site was very deep, 8 ft. or more, and it was considered wasteful to drive piles down to firm bottom. The first alternative tried was to nail cross-pieces on each pile and short boards across these latter. This arrangement no doubt would have kept the pile from sinking more than a short way, but the cross-pieces jarred off when the piles were driven. The method finally adopted was to drive dogs vertically into the side of the pile, but not quite home; a row of piles was then driven in a line, till the lower part of the dog reached the mud. A plank was then inserted through all the dogs of the row of piles; it was found that this plank, after a few more blows with a maul on each pile, prevented any further sinking. The piles were only 2 ft. or 3 ft. in the mud.

The details of the landing stage are given in *Fig.* 17.

Pile Driver.—Instead of having a separate pile driver, the guides for monkey were lashed to the pile itself, and the whole then upended into position; the monkey was then raised into position and iron girders fixed to keep it in place. This was thought to be quicker than having a separate pile driver with separate staging (*Fig.* 18).

Another Pile Driver.—This pile driver (*Fig.* 19) was constructed by three carpenters, a blacksmith and striker in 18 hours.

A party of 16 men pulled direct on the rope to raise the monkey.

The monkey could be dropped by the men letting go of the rope. But a slightly higher speed of working and more efficient blows were obtained by the use of an automatic catch to work the release. Six blows (of 15-ft. drop) a minute were delivered without special effort.

Although the men pulling on the rope were on the bank, no difficulty was experienced in mooring the raft.

Improvised Pile Driver.—*Fig.* 20 shows a pile driver improvised from Service equipment. The pile driver consists of two Weldon trestle legs standing on a half-sleeper, as base, which is spiked to the platform or bridgehead on which the driver works. A cross-bar is lashed to the tops of the legs to support the monkey, which is worked up and down by means of a pulley block lashed to the cross-bar. The monkey consists of a block of wood, 200 lbs. in weight, through which two holes are bored to take iron bolts 2 ft. 3 in. long. These bolts work up and down between the trestle legs, thereby keeping the monkey in position. The monkey has ½-in. iron bands round it, as shown on sketch. The pile driver is prevented from falling by four guys attached to any convenient holdfast.

The Weldon trestle legs are placed side by side on the head of the driver, fixed up and guys fastened. They can then be raised by the guys and shifted into position by mauls.

The monkey can then be put on. Six men will put up this pile driver in half an hour and get it into position. (It takes four men

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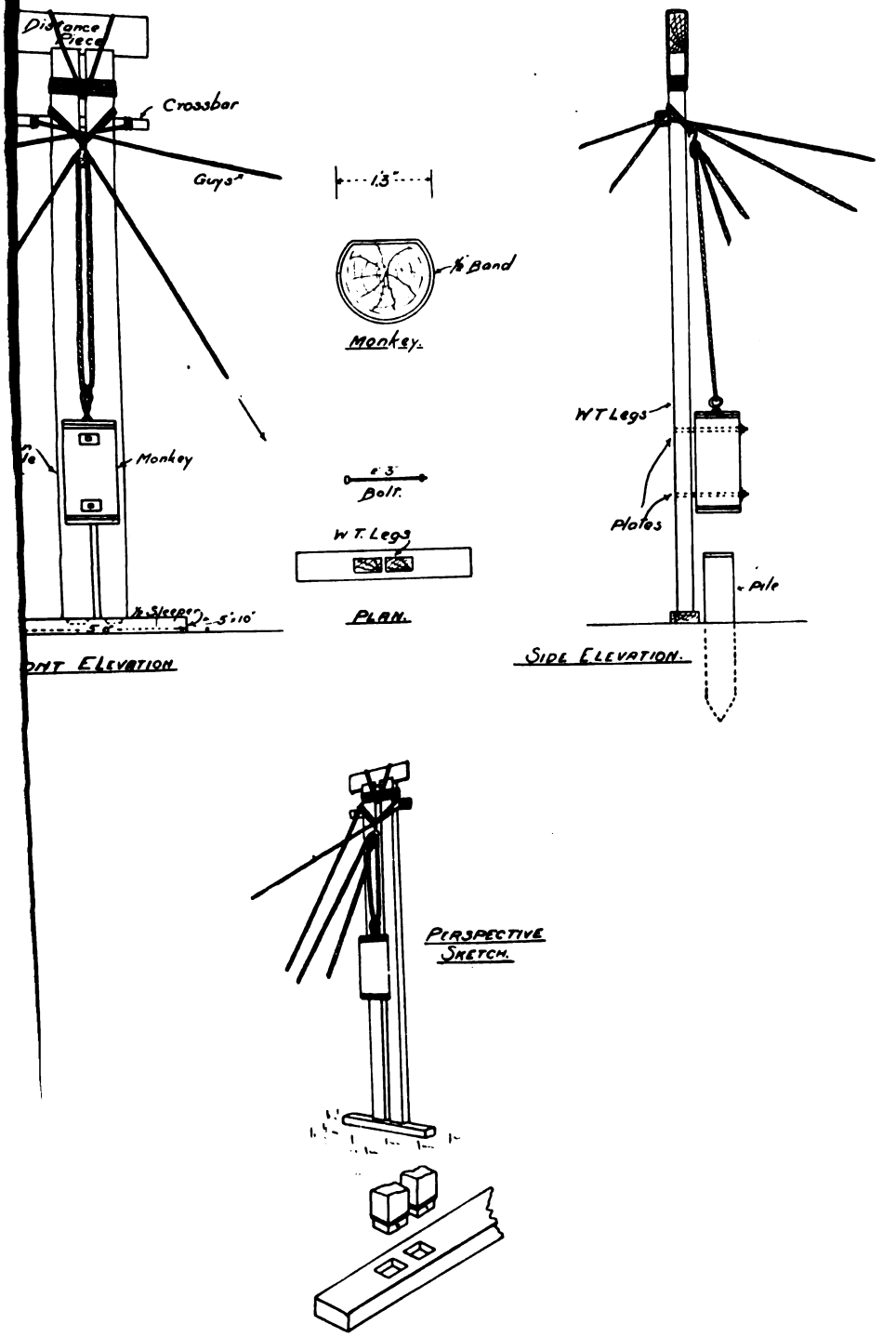

FIG. 20.—*Improvised Pile Driver.*

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ASTOR, LENOX AND
TILDEN FOUNDATIONS

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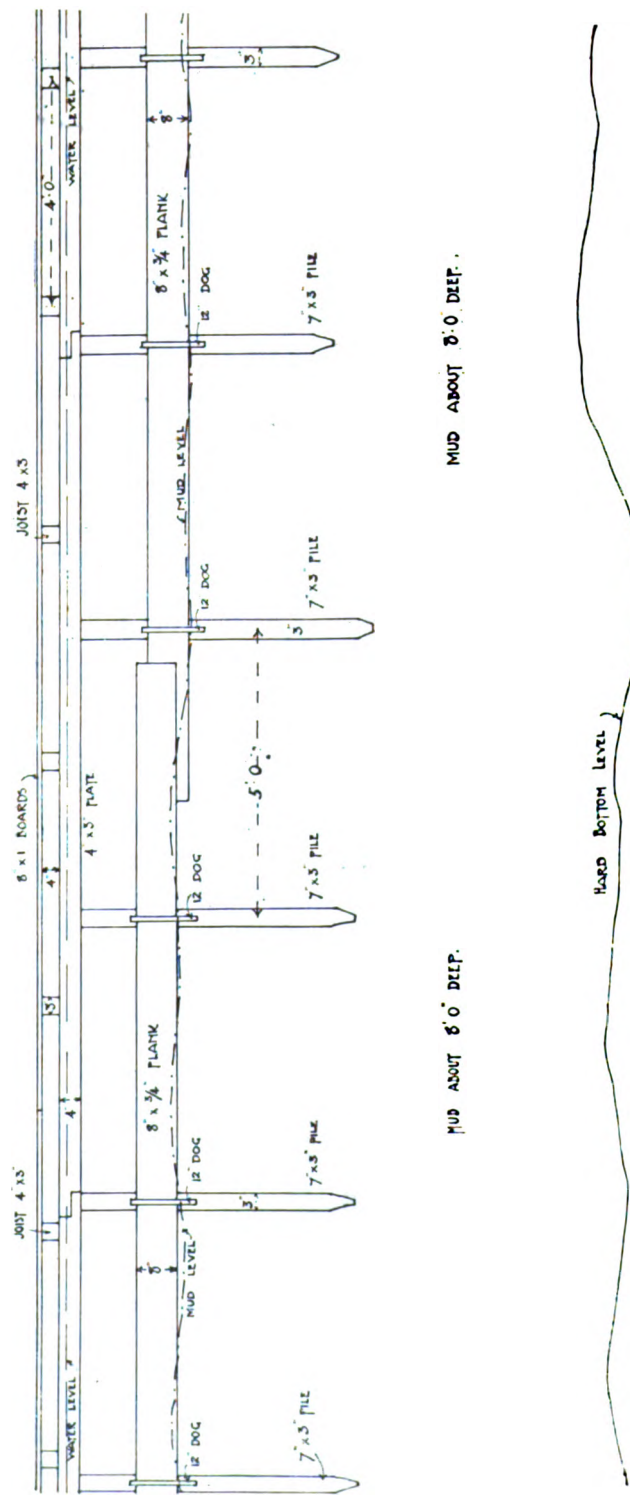

FIG. 17.—*Landing Stage in Mud.*

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to work it, and two reliefs are required; so that the whole detachment for working should consist of an N.C.O. and eight men).

Detail of Stores required:—The following are the stores required for the pile driver:—

2 Weldon trestle legs.
Blocks, 2 in.—1.
Lashings, 2 in.—12.
Pickets, 5 ft.—4.
2 half-sleepers halved for W.T. legs.
$2\frac{7}{8}$-in. bolts, 2 ft. 3 in. long, with nuts and plates.
Iron band, $\frac{1}{2}$ in. wide, $\frac{1}{4}$-in. stuff, 10 ft. length, for monkey.

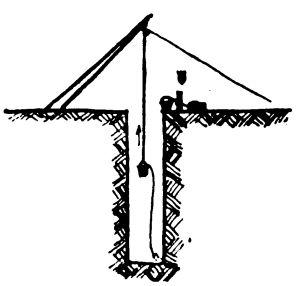
A spar 3 ft. long and 15 in. diameter to act as the monkey (weight about 200 lbs.) is also required. This would not need to be carried as it could probably be obtained locally.

A good deal of pile driving was done with this machine last summer with a detachment consisting of an N.C.O. and eight men; the average time taken was one hour per pile—this included fixing the pile driver each time and placing the pile in position. Each pile was driven in 5 ft. to 6 ft. and the time taken in actual driving was half an hour per pile. The bed of the river was of gravel, and at a depth of 3 ft. some hard rock was usually met with.

MINING AND DEMOLITIONS.

Methods of removing Excavated Earth from Shaft.

(*a*). Two buckets were used. The miners' bucket was not found convenient, owing to its small capacity and to the difficulty of emptying the wet clay out of it. The ordinary pails, I.G., were most useful.



Each bucket has a light rope, longer than the depth of the shaft, attached to it. As soon as the excavator has filled a bucket the spreader assists the hoisters to raise it with the sheers. Meanwhile, the N.C.O. in charge (or fifth man) lowers the other bucket by the hand rope, the excavator calling out where he wants it. This is done as soon as the up-going bucket is clear of the shaft. The N.C.O. takes a turn round the picket with the hand rope, and the

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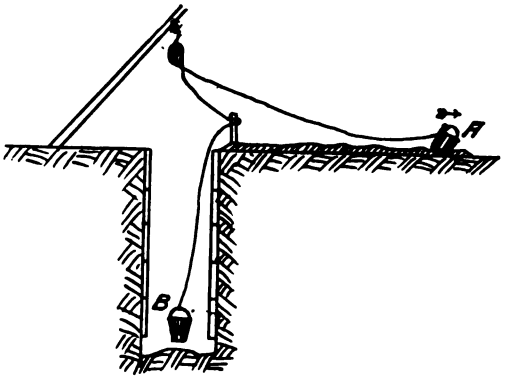
excavator starts filling the bucket. As soon as the first bucket has been detached the hook is lowered and one of the hoisters " fishes " for the bucket handle. This is quite easy after a little practice, and does not interfere with the excavator. The hand rope is then cast off the picket and the bucket is ready to be raised when full, the first bucket being placed ready by the shaft, to be lowered in its turn. It is convenient when working in this wet clay for the excavator to work directly into the bucket, and to have the bucket suspended a few inches above the floor of the shaft, hence the necessity for the picket.

(*b*). A rope is passed through the block, and a bucket is permanently attached to either end of it. The length of this rope must be not less than the depth of the shaft plus the distance that the spreader has to go to empty the bucket.



As soon as bucket A is filled it is hauled up by the hoisters pulling the rope through the block, and, as soon as it is clear of the shaft, the N.C.O. (or fifth man) lowers bucket B, and secures it with a turn round the picket, as in method (*a*). Meanwhile the spreader, assisted by one of the hoisters, walks away with bucket A and dumps the contents. This has the effect of hauling the slack through the block, the operation being assisted by the other hoister. As the slack is passing through the block the N.C.O. (or fifth man) casts the rope off the picket and the weight of the bucket B comes on the block. Bucket A is brought back to the shaft and placed ready in the position occupied by bucket B in figure.

This method was found very convenient, and was used for most of the time.

The simple method of using buckets attached by hooks to the ends of a rope equal in length to the depth of the shaft plus twice the height of the block, one bucket descending while the other ascends, was not found convenient, as the buckets fouled each other when passing in the shaft.

These methods were evolved owing to the necessity of having a

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bucket always at the excavator's hand. As he was working in several inches of water, it was quite useless for him to dig unless it was there for him to deposit the clay into.

The practice of lowering the empty bucket before raising the full one, the excavator changing the hook from one to the other, was found to waste time, and did not enable the buckets to be suspended clear of the floor.

Demolition of Lattice Girder.—A lattice girder was attacked three times, the charge being calculated by a modification of the method given in the text book for a plate girder, each case being completely successful, with the exception of one in which one of the detonators did not go off.

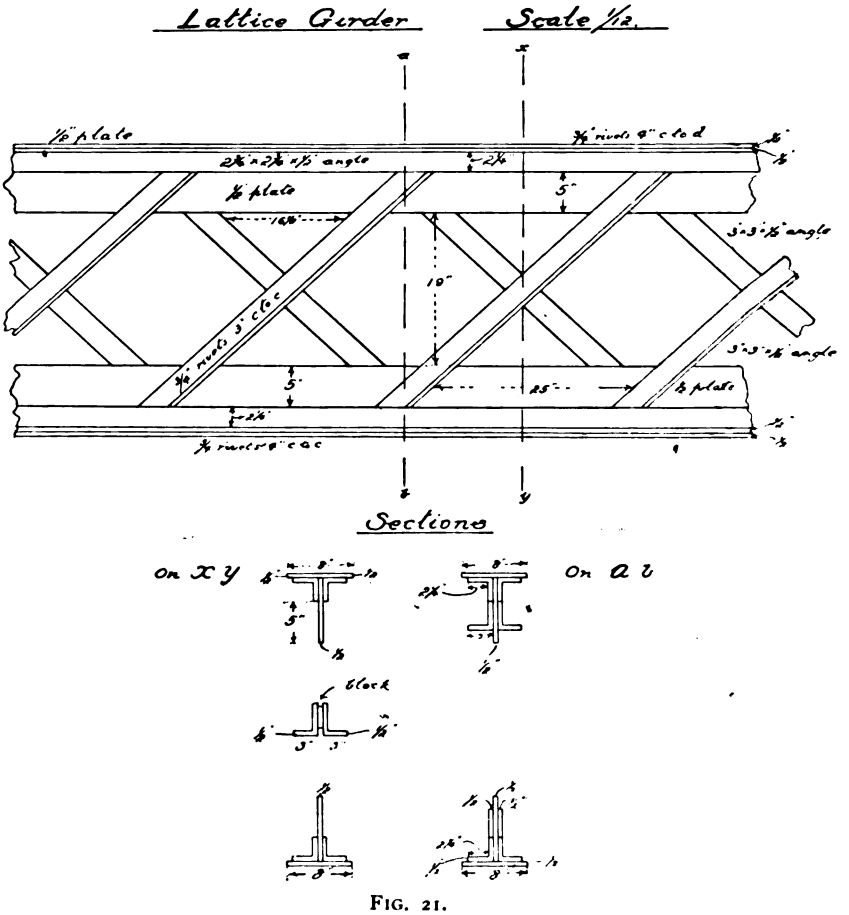

FIG. 21.

The charges were arranged in two different ways :—

(1). Three charges, one on each flange and one on the junction of the braces.

(2). Two charges on the flanges, so placed that no portion of the bracing was cut by a line joining them.

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The latter appears to be the better, as although the charges on the flanges are rather larger, owing to the gusset plates of the braces, etc., the third charge on the brace is saved and the total is not practically any greater ; whereas a saving of time, as well as a greater chance of success, is attained by having two charges instead of three. This would apply to *Fig.* 4, *Plate* 36, *Mil. Eng.*, Part IV.

Grenade-Throwing Catapult.—The idea of the catapult was to make a weapon capable of throwing a grenade about 1 lb. in weight at least twice the distance a like grenade could be thrown by hand. The catapult was to be light, so that it could easily be carried about.

The construction of the catapult is shown on *Fig.* 22 ; (A) shows the complete catapult, including tripod stand (not absolutely necessary for the use of the weapon).

The grenade (see *Figs.* (B) and (C)) consists of :—

1. The effective portion, *i.e.*, 4½ in. of 1½-in. iron pipe nearly divided into 48 pieces by hack-saw cuts as shown. Weight, 10 ozs., *i.e.*, each piece weighs about ⅕ oz.
2. The shaft, and plug for attachment of shaft (fixed by three ordinary ½-in. wood screws). Weight, 4 ozs.
3. The charge, which may be either one or two 1-oz. guncotton primers. Weight, 1 or 2 ozs.
4. Detonator and fuze, inserted from rear as shown, and bound in place by fine string. Weight, say 1 oz.
5. Clay tamping to keep the primer in place. Weight, say 1 oz.

Total weight of grenade :—

Shaft and plug	4 ozs.	
Detonator and fuze	1 oz.	
Iron piping	10 ozs.	
Primers	2 ozs. or	1 oz.
Clay tamping	1 oz.	
Total ..	18 ozs. or	19 ozs.

The head of the grenade slides in a V-shaped groove (see B). The shaft, ¾ in. by ½ in., slides in a groove ⅜ in. deep by ½ in. wide. The shaft is 3 ft. long, and is fitted with a 3-in. by 2-in. vane of copper sheet (24 gauge), to make the grenade fly true, and is notched at the back for reception of trigger-piece (see E). The trigger arrangement is shown in *Fig.* D.

The *Motive Power* consists of 8 strands of ⅜-in. elastic and 10 strands of $\frac{3}{16}$-in. elastic, each strand 1 ft. 3 in. long (unstretched) was stretched to a length of 4 ft. 3 in. when in loaded position. Each strand is fitted with a ¾-in. brass ring at each end, and is attached in front as shown in (B). The rear ring is looped over the turned-back portions of (E).

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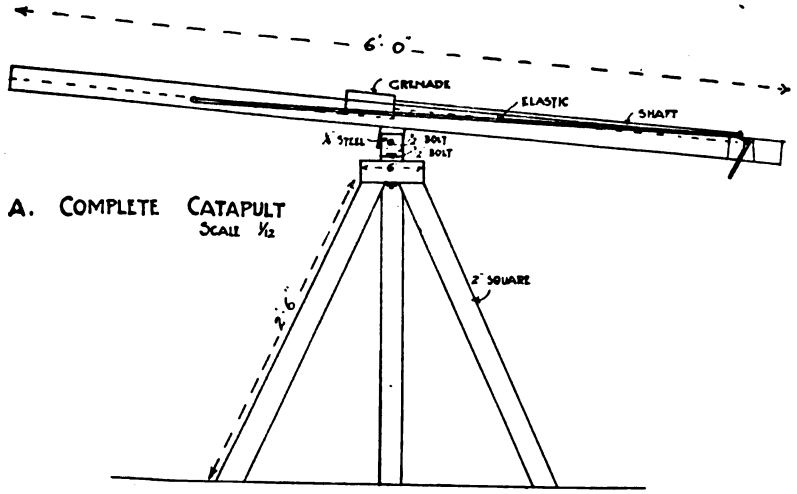

A. COMPLETE CATAPULT
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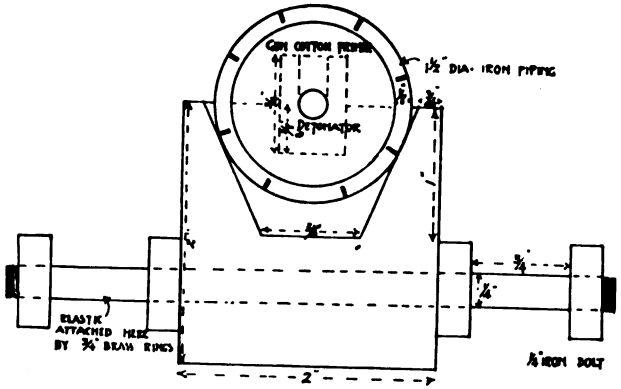
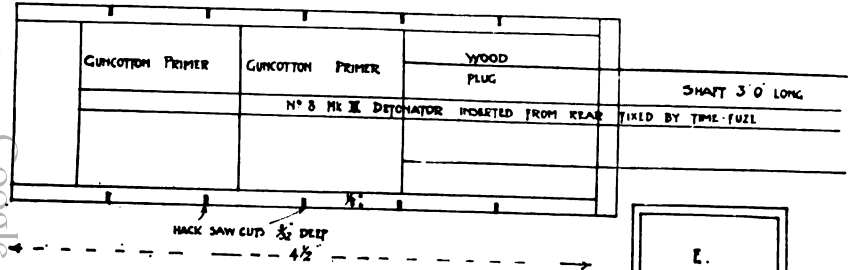


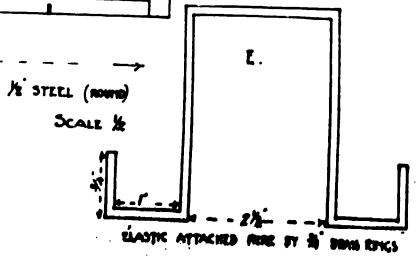
B. Elevation from Front.
Scale—Full Size.

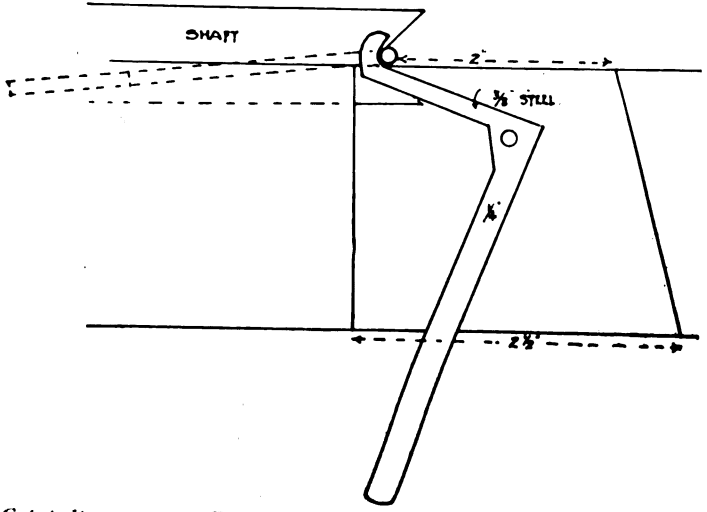


Weights.

Shaft and plug	4 ozs.
Detonator and fuze	1 oz.
Iron piping	10 ozs.
Primers	2 ozs.
Clay tamping	1 oz.
Grenade charged 2 ozs. G.C.	1 lb. 2 ozs.

C. Grenade (charged). Scale—Full Size.





D. Trigger Arrangement. Scale—Full Size.

FIG. 22.—*Grenade-Throwing Catapult.*

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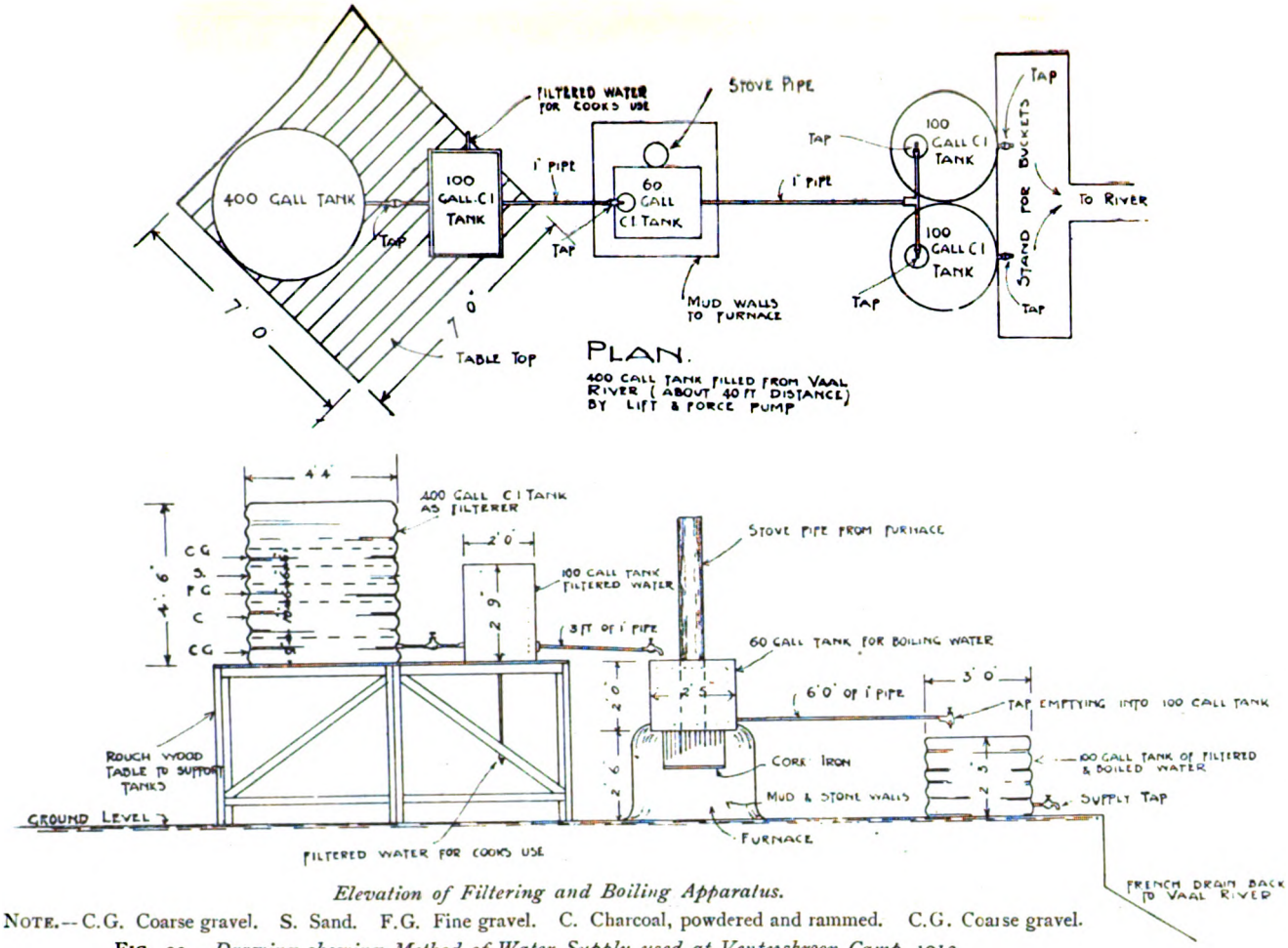

Elevation of Filtering and Boiling Apparatus.

NOTE.—C.G. Coarse gravel. S. Sand. F.G. Fine gravel. C. Charcoal, powdered and rammed. C.G. Coarse gravel.

FIG. 23.—*Drawing showing Method of Water Supply used at Venterskroon Camp*, 1913.

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The catapult is first loaded with one strand on each side and the remaining strands are put on in pairs, one on each side.

Pull required to stretch one strand $\frac{3}{8}$-in. elastic = 16lbs.

Pull required to stretch one strand $\frac{3}{16}$-in. elastic = 4 lbs.

Range was found to be 80 yards, nearly.

A trial was made by placing five dummies in the crater formed by the 150-lb. mine and firing from a range of 75 yards. The fourth grenade landed in the crater and exploded, hitting three out of the five dummies, one being very badly wounded.

There is no reason why the catapult grenade should not make a certainty of hitting a circle of 10-ft. diameter.

It is claimed that :—

(1). Its range is twice that of a hand grenade.

(2). Its accuracy is many times that of a hand grenade.

(3). It is sufficiently portable for use even by the besiegers, and is most suitable for the defenders to deny the occupation of a crater.

MISCELLANEOUS.

Field Kitchens.

The type actually used by regimental cooks on manœuvres usually consists either of a simple trench or of a fire with the camp kettles built up round and over it. For a small detachment, an excellent arrangement for holding pots over a fire can be made by fixing three or four iron dogs in the ground, and building the fire underneath.

Notes on Entraining 4-Wheeled Vehicles without Derricks or Sheers, etc.

(*a*). G.S. Wagon :—

(i.). Unload the wagon.

(ii.). Run it head first up to the door of truck and remove pole.

(iii.). Lock fore-carriage round square, insert pole under fore axle.

(iv.). Lift fore-carriage bodily into railway truck, manning up rear wheels to assist.

(v.). When well inside truck wheel fore-carriage up to one end and cross-lift rear wheels into truck.

The completed work should not take more than 3 minutes.

(*b*). Trestle or Pontoon Wagon :—

(i.). Unload wagon.

(ii.). Remove fore-carriage and lift it into railway truck and wheel to one end.

(iii.). Bring up remainder of wagon, the frame leading, and work the hind wheels through door.

(iv.). Roll the rear wheels to the opposite end of the truck and key up frame to fore-carriage.

The wagon can then be reloaded.

Water Supply.

An apparatus for filtering and boiling water for water supply is shown in *Fig.* 23.

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AN ACCESSORY TO THE BRIDGING EQUIPMENT.

By LIEUT. G. LE Q. MARTEL, R.E.

A FIELD COMPANY often has to bridge a small river or ditch from 15 to 20 ft. wide, and with the present bridging equipment, if the river is even 15½ ft. wide, a support has to be used in the centre, as the baulks are only 15 ft. long. The following is a short account of a collar that has been made for joining baulks side by side, so as to avoid having to use a support for spans just over 15 ft., and from the calculations shown below, it will be seen that by using five pairs of baulks in this way, it is possible to bridge a 19-ft. gap for field guns or infantry in fours. This is also very useful when the last span in a bridge is just over 15 ft.; for instance, if a river is 48 ft. wide, it could be bridged by a Field Company by using two pontoons, and the last span could then be crossed with baulks joined up for an 18-ft. span; this would save using a trestle (which generally causes some little delay), and the bridge built in this way would be just as strong as if the trestle had been used.

Fig. 2 shows, in plan, two plain baulks connected up for a 19-ft. span. *Figs.* 1 and 3 show details of the joint. The parts required

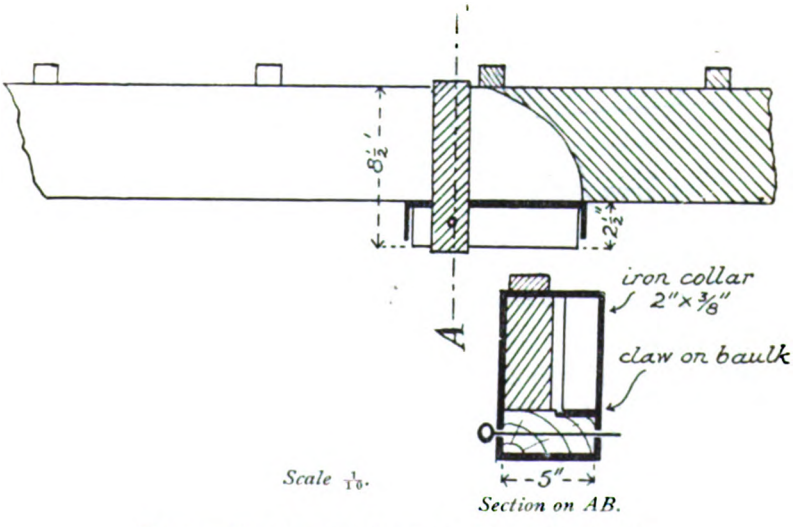

FIG. 1.—*Elevation showing joint of two button baulks.*

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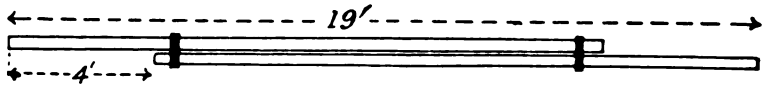
are an iron collar 8½ in. high, and 5 in. wide, and a block of wood 5 in. wide and 2½ in. thick. To connect up, two button baulks are first taken and placed as in *Fig.* 2. The most usual distance required is 19 ft., as this will take guns, but one of the baulks can be slid in or out to any required distance so long as it is an exact number of feet, so as to bring the buttons of one baulk opposite the buttons on the other. The iron collar is then slipped over one end of one baulk and pushed beyond the claws of the second baulk; the wood block is placed between the claws, and the iron collar slipped back to a position as shown in *Fig.* 1. The other end is treated in the same



Scale, 1" = 5'.

FIG. 2.—*Plan of two plain baulks joined for a 19' span.*

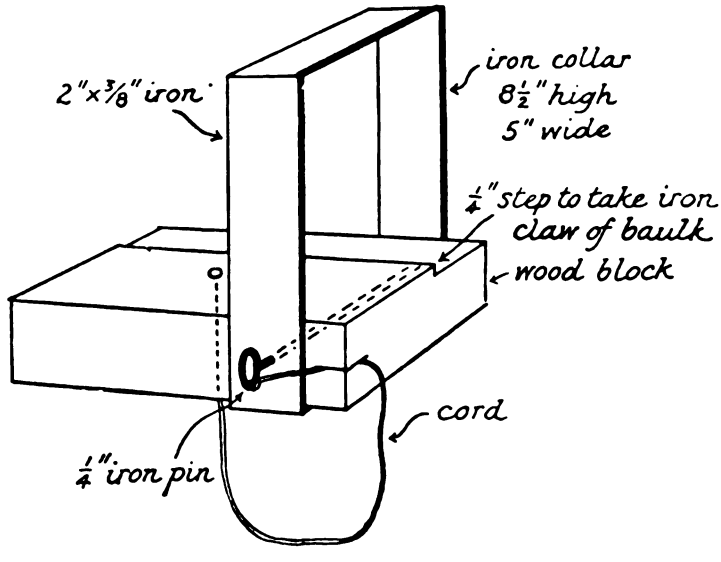


FIG. 3.—*Sketch showing parts required for joining baulks.*

way, and we have then a baulk 19 ft. long, and as strong, comparatively, as a single 15-ft. baulk. It is useful to remember that to get 19 ft., the first button on one baulk must be put opposite the fifth button on the other baulk. The plain baulks can be connected in the same way, but, in this case, the block can be put straight in its place, and the iron collar slipped over from the end, as there are no

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buttons to foul the collar. The wood block cannot slip out because it is held by the claws at the end of the baulk, but the iron collar might slip, and a pin of $\frac{1}{4}$-in. iron is therefore used, which passes through the collar and block. This pin is attached to the block by a piece of strong cord. In order to prevent the pin from falling out of its place, a saw cut is made as in *Fig.* 3 on the corner of the block, and when the pin has been pushed home the cord is forced into the cut, thus holding the pin. This avoids having to use a small contrivance, such as a hinged end to the pin or some similar arrangement, which would possibly jam or break. A $\frac{1}{4}$-in. step has to be cut on one side of the wood block to allow room for the iron claw on the end of the baulk. After a little practice a set of baulks can be connected up for a 19-ft. span in a few minutes.

Calculations.—Take first of all the ordinary bridging baulk 15 ft. long. Five of these will take infantry in fours crowded at a check, *i.e.* each baulk takes a distributed equivalent dead load of $\frac{5}{4}$ cwt. per foot-run.

Hence the M_{ff}

$$= \frac{wl^2}{8} = 35 \text{ ft.-cwt.}$$

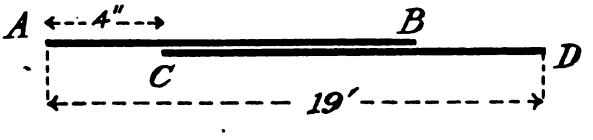
and the M.R.

$$= \tfrac{1}{6} rbd^2 = \tfrac{1}{6} r \times \tfrac{3}{12} \times (\tfrac{6}{12})^2 \text{ ft. units} = \frac{r}{96}.$$

Equating these

$$r = 96 \times 35 \text{ cwt. per square foot.}$$

This comes to 24 cwt. per square inch, which can therefore be taken as a safe working load.



Now take a pair of baulks extended to 19 ft.

In the above figure AB represents one baulk and CD the other.

Taking the load, as before, of $\frac{5}{4}$ cwt. per foot-run the B.M. at the centre is

$$\tfrac{5}{4} \times \tfrac{1}{8} \times (19)^2 = 56 \text{ ft.-cwt.}$$

and the M.R. is

$$r \times \tfrac{1}{6} \times \tfrac{6}{12} \times (\tfrac{6}{12})^2 = \frac{r}{48} \text{ ft.-units;}$$

hence

$$r = \frac{48 \times 56}{144} \text{ cwt. per square inch} = 19 \text{ cwt. which is quite safe.}$$

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Now take the point C.
The B.M. at this point is

$$\frac{5 \times 19}{8} \times 4 - \frac{3}{4} \times 4 \times 2 = 37{\cdot}5 \text{ ft.-cwt.}$$

And the section of the beam at this point is $2\frac{3}{4}$ in. $\times$ 6 in.;

hence M.R. $= \frac{1}{6} rbd^2$

$$= \frac{11r}{1152};$$

hence $$r = \frac{1152 \times 37{\cdot}5}{11 \times 144} \text{ cwt. per square inch}$$

$$= 27 \text{ cwt. per square inch.}$$

This is just slightly more than the working stress for the ordinary 15-ft. bay with single baulks, but it must be remembered that infantry will very seldom be crowded up sufficiently close on a 19-ft. bay to give a distributed load of 5 cwt. per foot-run.

A bridge made with double baulks extended to 19 ft. was tested with infantry crowded in fours, both marking time and standing still, and stood the test satisfactorily. Field guns were also taken over the bridge, but these bring a considerably smaller load on to a 19-ft. span than infantry in fours crowded.

The strain in the iron collar is quite small and a large factor of safety is provided by using 2-in. $\times$ $\frac{3}{8}$-in. iron.

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REMOVAL OF A BUILDING INTACT.

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REMOVAL OF A BUILDING INTACT.

By MAJOR N. M. HEMMING, R.E.

ALTHOUGH the removal of large buildings bodily to a new site is a comparatively common occurrence in America, it is less common in this country, and it is thought that an account of such a removal, although on a small scale, which has lately been carried out in the Royal Arsenal, may be of interest to officers of the Corps, as instances may occur in other places where conditions favour this mode of removal.

An improvement to a railway approach involved the taking down and rebuilding of a steel-framed building with brick panel walls 6 ft. high, filled in above with sashes and corrugated iron to eaves. The size of the building was 30 ft. × 15 ft. × 11 ft. 3 in. and the approximate cost for reconstruction, including taking down, was estimated at £100.

It was decided to move the building bodily to its new site, as the Arsenal Railway passed both the old and the new site, the distance between the two being some 70 yards; but the building might equally well have been moved any distance served by the railway as the traction presented no difficulties. The removal was successfully carried out at a cost of £35, and no portion of the building showed any signs of having been strained.

The method adopted was as follows:—

Four holes were cut in the brickwork close above floor level on each side wall, through which were passed four No. 12-in. × 12-in. timber needles. These were left projecting beyond each wall 4 ft.

In order to stiffen the building four stiffening pieces of 10-in. × 10-in. timber were cut and fixed across the building (inside) between the top longitudinal beams of building and vertically over the needles. 9-in. × 3-in. deals were laid on the top of the brick side walls, and short upright 10-in. × 10-in. timbers were fixed in between the 3-in. deal and 10-in. stiffeners referred to above. Four pairs of cross struts were fixed from the 10-in. × 10-in. stiffeners, on the one side, to the needles on the other. Four pairs of longitudinal braces, two at each side wall, were also fixed between the 10-in. stiffeners and the needles.

The bottom course of brickwork was cut away and the six stanchions of building sawn off close to the top of the old foundation. A 2½-in. wire rope was passed around the building about 3 ft. above floor level and was tightened up with a union screw. Hydraulic jacks were then placed under the timber needles and the building was lifted up 3 ft., this allowed of 10-in. × 10-in. timbers being placed under the side walls of building, two on each side about 3 ft. apart

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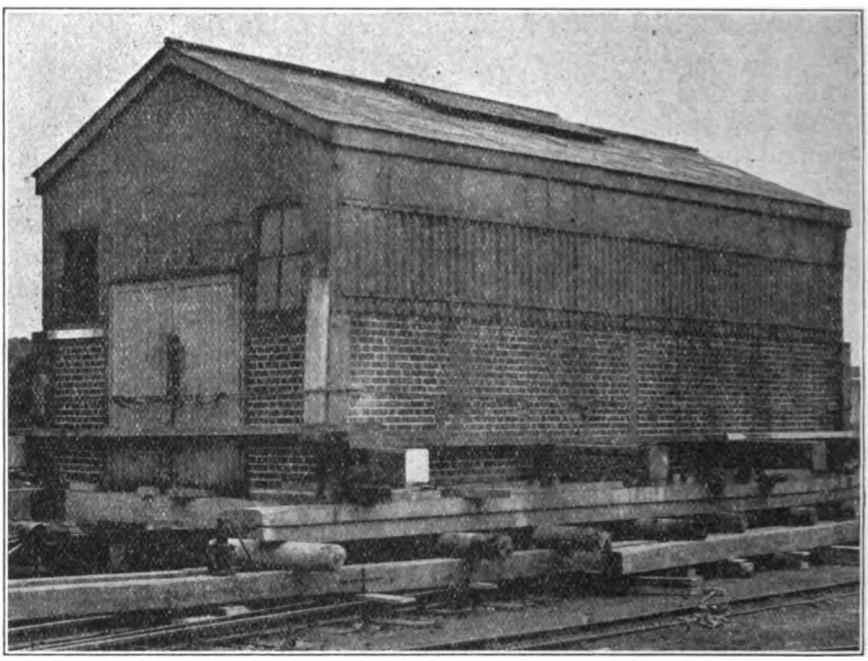
to act as roller paths to carry the 10-in. rollers, as shown in the photograph.



A wooden cradle, the size of the building, had been previously prepared, made from 14-in. × 14-in. timbers, halved together and secured by iron knees.

This was now placed under the lowest course of brickwork, and the six stanchions were secured to the cradle by six pairs of steel knees. The building and cradle were then lowered down on to the rollers and another wire rope was passed around the cradling, to which was secured a 4-in. tackle. The actual hauling was done by a standard gauge locomotive engine.

On arriving at the new site, the building was with a little trouble turned through a right angle and got into its proper position over the new foundation which had, of course, been previously prepared; jacks were again placed under the needles and the weight taken off the rollers; the rollers and roller path were removed, the cradling unbolted from the stanchion knees and hauled out of the way, and the building lowered down on to its new foundation. The six pairs of stanchion knees were utilized for securing the building to the new foundation.

The whole of the above work was carried out without the smallest hitch under the direction of Capt. H. Mitchell, and, as will be seen above, a considerable saving was effected by thus removing the building bodily.

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DELHI CORONATION DURBAR, 1911.

By COLONEL R. S. MACLAGAN, C.B., C.S.I., R.E.

1. THE Committee appointed to make preparations for the Durbar was constituted as follows :—

PRESIDENT.

Sir J. P. Hewett, G.C.S.I., C.I.E.

MEMBERS.

Representative of Foreign Office.—Sir A. H. McMahon, G.C.V.O., K.C.I.E., C.S.I., Foreign Secretary.

Railways.—Sir T. Wynne, K.C.S.I., K.C.I.E., President of the Railway Board.

Civil Representative.—Colonel Dallas, C.S.I., I.A., Commissioner of Delhi.

Military Representative.—Brig.-General H. V. Cox, C.S.I., I.A.

Representative of His Majesty.—Brig.-General Sir R. Grimston, K.C.V.O., C.I.E.

Public Works Department.—Colonel R. S. Maclagan, C.B., C.S.I., R.E.

Medical and Sanitary.—Colonel C. J. Bamber, M.V.O., I.M.S.

Finance.—Mr. W. M. Hailey, C.I.E., C.S.

Representative of His Excellency the Viceroy.—Lieut.-Colonel Maxwell, V.C., C.S.I., D.S.O.

Supply and Transport.—Lieut.-Colonel Murray, M.V.O., Supply and Transport Corps.

Secretary.—Mr. E. V. Gabriel, C.V.O., C.S.I., C.S.

2. All matters connected with public works (except railways which were dealt with by Sir T. Wynne, President of the Railway Board, and works in military camps which came under the Military Member, Brig.-General Cox) were brought before the committee by the Public Works Department member, who was responsible also for seeing that the works sanctioned were properly carried out.

The chief departments under him and the officers in charge of them were :—

(A). Electrical.—Mr. J. S. Pitkeathley, C.V.O.

(B). Water Supply.—Mr. D. W. Aikman, Sanitary Engineer, Punjab.

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(C). Roads and Buildings.—Major Crookshank, M.V.O., R.E.

(D). Canals.—Mr. Ward, C.I.E., M.V.O., Superintending Engineer, Irrigation Branch, Punjab.

Telegraphs and Post Office were directly under the Government of India and not under the Durbar Committee.

For the garden party, which the committee decided to hold in the Fort, the general arrangements for preparing the buildings and gardens inside the archæological area were carried out by the Local Public Works Department, under Rai Sahib Bishamber Nath, Executive Engineer, Punjab. The electric light was in charge of Capt. Malan, R.E., Military Works Services, and arrangements outside the archæological area by Capt. A. Campbell, R.E., Military Works Services.

3. A report on the electrical works will I understand be presented by Capt. Barker, M.V.O., R.E., who was Mr. Pitkeathley's senior assistant, and on canals by Lieut. Sopwith, R.E. Other Royal Engineer officers will also report on the works of which they were in charge. It remains therefore for me to briefly describe only those two items on which no Sappers were employed, viz., waterworks and preparation of archæological buildings in the Fort.

WATER SUPPLY.

1. This was in charge of Mr. D. W. Aikman, C.E., Sanitary Engineer, Punjab.

The Delhi Municipality at the time when the preparations for the Durbar were taken in hand, early in 1911, contemplated an increase of their water supply by adding extra pumping plant and filter beds and a new rising main from their head works on the Jumna to the Reservoir on the Ridge. The Durbar Committee entered into an agreement with the Municipality whereby the latter agreed to allow the Durbar Committee to take from their reservoir, on payment of a sum of Rs.90,000 to cover the cost of supplying temporary plant extra establishment, coal, use of existing plant, etc., the following quantities of water :—

Month.	Total Quantity in Gallons per Month.	Maximum in One Day.
July	9,000,000	500,000
August	9,000,000	500,000
September	9,000,000	500,000
October	18,000,000	1,000,000
November	30,000,000	1,500,000
December	45,000,000	1,700,000
	120,000,000	

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These figures were based on the anticipated consumption calculated from the demands in the Durbar of 1903, but as a matter of fact were largely exceeded, the actual quantity supplied being:—

Month.	Total Quantity in Gallons per Month.	Maximum in One Day.
July	8,187,000	672,000
August	19,387,000	1,010,000
September	26,851,000	1,407,000
October	23,265,000	1,309,000
November	26,155,000	1,864,000
December	48,935,000	3,097,000
Total	152,780,000 gallons.	

In addition, the following quantities were given by temporary pipes to working parties:—March, 899,000 gallons; April, 3,480,000; May, 3,596,000; June, 3,480,000; total gallons, 11,455,000.

That is, a total of 164,235,000 were pumped to the Durbar area up to end of December, 1911.

2. As the head works and rising main were in charge of the Municipality, the Durbar supply proper commenced from the Reservoir on the Ridge, though Mr. Aikman in his capacity as Sanitary Engineer, Punjab, was also responsible for the new work carried out by the Municipality which comprised:—

(*a*). Providing and erecting a triple expansion pumping engine with Babcock and Wilcox boiler (all manufactured in England shipped and erected within six months).

(*b*). New rising main to settling tank.

(*c*). 3 large slow sand filters.

(*d*). 1 large Jewell filter with engine, buildings, etc.

(*e*). Constructing two covered clear-water reservoirs of 1¼ million gallons capacity.

(*f*). Supplying and erecting 2 new compound pumping engines and other minor items.

3. In the Durbar area the following work was done:—C.I. pipes from 3 in. to 20 in., 52 miles, weighing 4,152 tons; galvanized iron pipes, 65 miles; tanks:—3 of 100,000 gallons, 1 of 50,000 gallons, 1 of 781 gallons, 144 of 400 gallons, 18 of 300 gallons; total, 413,781 gallons; hydrants, 48 gallons; standposts and taps, 2,234 gallons.

4. The work was carried out by Messrs. Martin & Company of Calcutta, all C.I. pipes above 4 in. in diameter being obtained from England. The firm were given the contract on 17th February, 1911, and water was delivered to all parts of the Durbar area by 18th September. Under the terms of their contract they were responsible

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for maintenance of the pipes laid by them up to end of December, and they were paid at the rate of Rs.6/13/- per cwt. of pipe laid over 5-in. diameter, and Rs.6/10/- per cwt. for pipes of under 5 in. which were of Indian manufacture.

5. With regard to maintenance, Mr. Aikman reports " The maintenance was particularly difficult as all the pipes were brought out and laid in the blazing sun between the end of May and the end of August. There was hardly any rainfall during this period. The pipes got so hot that the pipe layers could scarcely handle them. The contraction due to cooling in the cast-iron mains was very great. Something had to go. Luckily there were only 3 bursts, and 4 or 5 pipes split slightly due to the strains of contraction. About 28 leaks occurred, due to the contraction pulling the spigot partly out of the socket. There were no leaks in the mains after December the 1st onwards.

I had the same difficulty, but in a lesser degree, with the distribution pipes—these being galvanized wrought iron could stretch against the contraction from cooling, but the strain caused leaks at the threads of the joints. Owing to the consignment of taps being delayed on the railway, I had to use, as a temporary measure, country-made plug taps which with very little rough usage soon began to leak, and more complaints were received from this cause than any other until they were replaced by taps of English manufacture."

6. The system adopted for maintenance was to form depôts at convenient centres where gangs of men with material for repairs were kept ready to start off when notice of a burst was received. Five such depôts in all were formed, and they were, whenever possible, connected with the telephone system. Mr. Aikman reports. " Repairing cards were printed as shown below :—

DURBAR WATER SUPPLY.

Camp No.

Send men to repair 1, leak in tap ; 2, leak in G.I. pipe ; 3, leak in main pipe ; 4, burst in main pipe.

Note.—A large X should be put on the line applicable to the nature of the repair opposite 1, 2, 3 or 4.

Bundles of these cards were sent to each camp officer, with printed instructions asking the camp officer, after filling in the card with the number of his camp and cross opposite the repair required, to send it with a verbal message to the repairing depôt for his camp. On receipt of the card one of the gang mistries at the depôt would send a man on a bicycle with (1) a new tap—if it referred to a tap—the defective tap being removed and taken to the depôt for repair ; (2), with the necessary repairing tools if a leak ; and (3) with keys.

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to turn off the ferrule or valves in case of a burst—and follow up with his repairing barrow and gang. Luckily there were no bursts on the mains during the Durbar period. The system worked well, but the reporting from camps was not always good, the repairing cards being often sent to me by post and hand instead of to the nearest repairing depôt. In most cases when taps were reported leaking the tap was found to be in good order but had not been turned off properly." In addition the mains were patrolled one man to every 2 miles. In all there were 137 men employed in the repair and patrol gangs.

7. The accounts have not yet been finally closed but the probable cost will be 4,46,666 gross, 2,35,122 net.

In addition Rs.2476 was spent in sinking wells for the Imperial Service Troops camp which was too far off to be connected with the rest of the system; 90,000 was paid to the Delhi Municipality as stated in paragraph (1) and Rs.100871 was spent on distribution pipes for water supplied to the several camps and paid for by them.

8. The water supply was, on the whole, very satisfactory but improvements might have been made in the following points:—

(1). The repairing gangs and system of reporting were not introduced early enough. It should have been started as soon as water was supplied and pipes drawn on.

(2). It would have been better to purchase taps of the best English manufacture, and to issue them to contractors rather than to allow them to provide them. It would have been worth the slight extra cost.

Garden Party.

The Durbar Committee selected the archæological area within the Fort as the place in which to hold a garden party on the afternoon of the 13th December. During 1910, a portion of this area, known as the Hayat Bakhsh Garden, 3·63 acres in extent, had been restored from archæological funds, the old water channels reconstructed and plots between them laid out in grass lawns and flower beds. It was decided that the remainder of the archæological enclosure, a space of 6·87 acres, should be laid out in the same manner. This had always been contemplated by the Archæological Department, but would, but for the occasion of Their Majesties' visit, have been carried out gradually when funds admitted instead of being done in one year. The total estimated cost of the improvements in the Fort was Rs.99,700, of which the Durbar Committee contributed 25,000.

The works consisted chiefly of the following:—

(*a*). The ground, which was largely composed of débris from old buildings demolished at the time of the Mutiny, was first cut down to its original level, and the old water channels of the Moghul time were marked out by bajri paths, the borders of which were edged

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with low brick walls coped with red sandstone: the plots between these paths were laid out in grass lawns and shrubberies, the latter marking the sites of the old Moghul buildings which had been subsequently demolished.

(*b*). Water supplied for an elevated reservoir, which had been constructed in 1910 behind the building known as Bhadon in the Hayat Bakhsh Garden, was laid on to the marble channel which runs down the centre of the Palace buildings from the Hamman to the Rang Mahal, and also to the fountains and cascades in the Hayat Bakhsh Garden, and these played throughout the afternoon of the garden party the cascades being illuminated after dark by electric lights placed in the recesses behind them.

(*c*). A low ornamental parapet of red sandstone was erected on the Fort wall on the east side overlooking the Bela to replace an old and unsightly iron fence.

(*d*). As the old historical "jharokha"—a marble balcony projecting from the Fort wall at the Summun Burj—was too small for two chairs, the projecting balcony between the Sammun Burj and Rang Mahal was adapted as a "jharokha," by slightly raising a portion of the marble platform behind it, and here Their Majesties on the afternoon of the 13th December sat in state to watch the Badshahi Mela which was being held below.

(*e*). All the archæological buildings in Fort were repaired or restored, the chief works being the following:—

(1). The Mumtaz Mahal—formerly used as a Sergeants' Mess—was restored, modern additions to the building being removed, and was occupied by the Museum of Archæology which had hitherto been housed in the small rooms on the ground floor of the Naubat Khana. A fine collection of articles of historic and archæological interest, mostly obtained on loan from ruling chiefs and Indian gentlemen, were here exhibited during the period of the Durbar.

(2). The roof of the Diwan-i-Khas was restored and regilded.

(3). The Rang Mahal was thoroughly repaired and a new ceiling put on.

The above works were carried out under the superintendence of Mr. Gordon Sanderson, Superintendent, British and Muhammadan Buildings, Northern Circle, by Rai Sahib Bishamber Nath, Executive Engineer, Public Works Department, Punjab.

In addition to the above, the Punjab Public Works Department staff made temporary arrangements for the accommodation of pardah nashin ladies on the roof of the Mumtaz Mahal and Naubat Khana.

By the same agency, also, an insanitary ditch in the Bela just below the Fort wall was filled up and the jungle on the Bela cleared.

There was nothing in the execution of these works which were of special interest from an engineering point of view.

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EARLY INDIAN CAMPAIGNS AND THE DECORATIONS AWARDED FOR THEM.

(*Concluded*).

By MAJOR H. BIDDULPH, R.E.

These notes have now embraced the period referred to in the introduction, viz. :—1799—1849 ; but, as the war with China in 1840–2 was carried through almost exclusively by troops from India, a few remarks on the composition of the force and the medal granted for that campaign may not be out of place. The same medal (with the omission of the date) was granted for the subsequent war with China in 1857–60, and notes on this medal necessarily include the clasps granted for that war ; and, on account of the fact that the Indian Army was in a transition stage, after the Mutiny, a list of the H.E.I.C. troops employed in China, 1857–60, is given with their designations taken from the medal rolls. In an appendix a similar list is given for the Persian Campaign of 1857 ; as also certain naval lists which will prove of interest to the collector who specializes.

CHINA WAR, 1840–2.

The occasion of this war was the destruction by the Chinese of British property, valued at £2,500,000, in a violent effort to stop the opium trade. On account of the sea voyage the only Native troops sent from Bengal were volunteers, the bulk of the force being supplied by the Madras Presidency. A good deal of hard fighting took place, before the Chinese sued for peace, which they did just before the British prepared to advance on Nanking. The British possession of Hong Kong dates from this period.

H.E.I.C. Troops that served in the War.

Madras Artillery :—
- C Troop, Horse Brigade.
- B and C Cos. 2nd Battn.
- D Co. 3rd Battn.
- A, B, C, D Cos. China Gun Lascars.

Madras Sappers & Miners :—
- A, B and F Cos.
- Details of C, D and E Cos.

Bombay Artillery :—
- Native detachments serving on board ship.

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Infantry :—
1st Regt. Bengal Volunteers.
2nd Regt. Bengal Volunteers.
2nd, 6th, 14th, 37th and 41st Madras N. Infantry.*
Rifle Company and details of 36th Madras N.I.

List of Officers of the Madras Engineers who served in China, 1840-2.

Capt. T. T. Pears.
Lieut. F. C. Cotton.
Lieut. W. I. Birdwood.
Lieut. J. C. Shaw.
Lieut. J. W. Rundall (wounded).
Lieut. J. Ouchterlony.
Lieut. J. G. Johnston.
Lieut. H. W. Hitchins.

For this war a silver medal (described below) was granted, without any clasps ; the suspender being a straight German-silver bar secured to the medal by two concealed pins.

For the war in 1857–60, the same medal (with the date 1842 omitted) was granted, but with a modern curved silver-bar and swivel mounting; and five clasps in all were authorized for the war; a sixth clasp, " China 1842," being granted to those few individuals who were in possession of the medal for 1842.

Medal :—China, 1840–2, 1857–60.

Silver 1·4-in. diameter.
Obverse.—Crowned head of Queen Victoria. Legend " Victoria Regina."
Reverse.—A trophy. Inscription " Armis exposcere pacem." " CHINA 1842."
N.B.—" 1842 " is omitted from the medal struck for 1857–60.
Ribbon.—1¼ in. wide. Red with yellow edges.
Mounting.—(*a*) 1842. Straight German-silver bar.
(*b*) 1857–60. Curved silver bar with swivel.
Clasps.—" China 1842."
" Fatshan 1857" (Navy only).
" Canton 1857."
" Taku Forts 1858 " (Navy only).
" Taku Forts 1860."
" Pekin 1860."

* The 37th M.N.I. was sent out from India in 1840 ; the 36th M.N.I. in 1841 ; the 2nd Regt. Bengal Volunteers, and 2nd, 6th, 14th, and 41st M.N.I. in 1842.

The 39th M.N.I. garrisoned Hong Kong in 1842, but did not receive the medal.

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H.E.I.C. Troops which served in China, 1857–60.

Artillery :—A Co. 5th Battn. Madras Artillery (1860).
1st Supplemental Co. 5th (Golundaz) Battn. Madras Artillery (1860).
Detachment of Bombay Artillery (and Infantry) serving as Marines.
Sappers & Miners :—A and K Cos. Madras Sappers & Miners (1860).
Cavalry :—1st Sikh Cavalry (later 11th Bengal Cavalry) (1860).
Fane's Horse (later 19th Bengal Cavalry) (1860).
Infantry* :—7th (late 47th) Bengal N.I. (1858–60).
10th (late 65th) Bengal N.I. (1858–9).
11th (late 70th) Bengal N.I. (1858–9).
Detachment 3rd (late 32nd) B.N.I. serving with the 10th (late 65th) B.N.I. (1858–9).
New 15th Bengal N.I. (Ludhiana Sikhs) (1860).
,, 20th Bengal N.I. (late 8th Punjab) (1860).
,, 22nd Bengal N.I. (late 11th Punjab) (1860).
,, 23rd Punjab Pioneers (late 15th Punjab) (1860).
,, 27th Bengal N.I. (late 19th Punjab) (1860).
Detachment 12th, 29th and 38th Madras N. Infantry (1857).
5th Bombay N. Infantry (1860–2) ; details of 3rd Bo.N.I.
Detachment 21st Bombay N.I. (Marine Battn.) serving as Marines.

From the despatch of the Secretary of State for India to the Governor-General on the subject, and from the 1857–60 medal rolls, it is quite clear that those men who served in *both* wars received in the first instance *only the clasps* to which they were entitled, including the " China 1842 " clasp.

It appears to have been overlooked that the suspender of the " China 1842 " medal was not adapted for the addition of clasps ; but this seems to have been discovered after the issue of the loose clasps had commenced, and medals from the 1857–60 die were then sent out to enable the clasps to be properly fixed. How many of the recipients did this cannot be determined, as the majority were in the Royal Navy, whose medals in 1860 were issued unengraved ; but some undoubtedly had already fixed their clasps to the 1842 medal by altering the original suspender at their own expense.

It may be safely said that very few of the unengraved China

* The 21st Madras N.I. garrisoned Hong Kong in 1860, but did not receive the medal. The 3rd Bombay Infantry were also despatched from India to China in 1860, but only a few details earned the medal.

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medals with the "China 1842" clasp are *bona-fide* issues. The number of men who earned the "China 1842" clasp are as follows :—

Royal Navy :—93 in all (including 24 officers).

Army :—6 Europeans and 16 Natives.

Indian Marine :—1 European.

Several of these Natives died before the issue took place, and their medals and clasps were returned to the Horse Guards to be melted.

APPENDIX I.

H.E.I.C. TROOPS WHICH SERVED IN PERSIA, 1857.

Artillery :—Detachments of Bombay Artillery.
Sappers & Miners :—Detachments from Madras and Bombay.
Cavalry :—3rd Bombay Light Cavalry.
Detachment Poona Irregular Horse.
Scinde Irregular Horse.
Aden Irregular Horse.
Infantry :—1st and 2nd Bombay European Regiments.
4th, 20th, 23rd and 26th Bombay N.I.
2nd Belooch Battalions.
Detachments of 2nd, 3rd, 5th, 6th, 8th, 9th, 11th, 15th, 19th, 22nd, 25th, 28th, 29th and Marine Battalion (21st) Bombay N.I.

APPENDIX II.

LISTS OF VESSELS OF THE INDIAN NAVY EMPLOYED IN VARIOUS CAMPAIGNS.

CHINA, 1840–2.

Bengal Marine.

Enterprise.
Hooghly.
Madagascar.
Nemesis.
Phlegethon.
Pluto.
Proserpine.
Queen.
Tenasserim.

Indian Navy.

Ariadne.
Atalanta.
Auckland.
Medusa.
Sesostris.

CHINA, 1857–60.

Indian Navy.

Auckland.
Berenice
Coromandel.
Ferooz.
Prince Arthur.
Zenobia.

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Scinde Campaign, 1843.

The list of vessels employed has been given previously. 110 men in all of the "Indus Flotilla" earned the Meeanee medal, and 115 men that for Hyderabad.

Punjab Campaign.

154 Europeans served with the "Indus Flotilla" and earned the medal; some of them receiving the clasp for "Mooltan" as well.

Army of India Medal.

300 medals with the clasp for "Ava" were issued to the Royal Navy, and 46 to European survivors of the Indian Marine. The names of the vessels employed have been given on p. 237, Vol. 18.

Burma, 1852–3. (Medal and clasp "Pegu").

Bengal Marine.	*Indian Navy.*
Bhageruttee.	Berenice.
Damoodah.	Ferooz.
Enterprize.	Medusa.
Fire Queen.	Moozuffer.
Indus.	Sesostris.
Krishna.	Zenobia.
Lord Wm. Bentinck.	
Luckea.	
Mahanuddy.	
Nemesis.	
Nerbuddah.	
Phlegethon.	
Pluto.	
Proserpine.	
Soane.	
Spy.	
Sutledge.	
Tenasserim.	

Persia, 1857. (Medal and clasp "Persia").

Indian Navy.

Ajdaha.	Euphrates.	Planet.
Assaye.	Falkland.	Punjaub.
Assyria.	Ferooz.	Semiramis.
Berenice.	Hugh Lindsay.	Victoria.
Clive.	Lady Falkland.	
Comet.	Napier.	
Constance.	Nitocris.	

Indian Mutiny.

300 Europeans of the Indian Marine received the medal. These medals are marked as a rule "Indian Naval Brigade," that being the designation of the force. No clasps were earned by this force.

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As regards the Royal Naval Brigade, H.M.S. *Shannon* earned 530 medals, and H.M.S. *Pearl* 232 medals.

In nearly all these campaigns a certain number of Bombay Native Artillerymen received medals, who served on board ship as Marines. The numbers given above do not include these men, as they were only lent by the Army.

FINIS.

ERRATA.

Vol. XVIII., 1913.

P. 41, line 28.—*Omit* sentence in brackets.
P. 42, line 17.—*For* " first " *read* " second."
P. 89, line 41.—*For* " 64 " *read* " 73."
P. 96, line 10.—*For* " Divisions " *read* " Division."
P. 96, line 24.—*For* " J. Robertson " *read* " T. Robertson."
P. 98, line 26.—*For* " J. Robertson " *read* " T. Robertson."
P. 98, line 31.—*For* " Gohna " *read* " Gohad."
P. 98, line 39.—*For* " ATTACK " *read* " CUTTACK."
P. 171, line 36.—*For* " 1-4th M.N.I." *read* " 1-2nd M.N.I."
P. 178, line 20.—Add the name of Lieut. J. Peckett, Bengal Engineers.
P. 236, line 12.—*For* " to " *read* " for."
P. 288, line 3.—*For* " 2-6th Brigade " *read* " 2-6th Battalion."
P. 291, line 3.—*For* " are " *read* " is."
P. 298, line 21.—*For* " Dalhousie " *read* " Ellenborough."
P. 338, line 18.—*For* " R. Blackall, 50th B.N.I." *read* " J. Anderson 50th Foot, vice Blackall, sick."

Vol. XIX., 1914.

P. 41, line 2.—*For* " W. Wallace " *read* " N. Wallace."

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TRANSCRIPT.

ON AN INDIAN CANAL.

By MAJOR-GENERAL G. K. SCOTT-MONCRIEFF, C.B., C.I.E.

(Reproduced from Nos. MCXII., MCXIII. *and* MCXIV., BLACKWOOD'S MAGAZINE, *with the permission of the Proprietors,* MESSRS. WM. BLACKWOOD & SONS, LONDON AND EDINBURGH).

A STORY was current in the Punjab a few years ago that a young and zealous district officer, who had just been transferred to the province from some other place, and had made his first cold-weather tour of his new territory, reported that he had in the course of his wanderings come across a broad and majestic river. He further stated that this river was not marked on any of the survey maps in his possession, and, improving the occasion, he took the opportunity to criticize in scathing periods the administration of Government departments (other than the covenanted civil service) in general, and the shortcomings of the Survey of India in particular. The story goes on to say that the report of this officer, after passing through the usual channels of correspondence, eventually found its way to Simla, that there it passed about from one branch to another until it was ultimately answered, and the zealous officer in question was informed that, from circumstantial evidence, it appeared that he must have discovered the Sirhind Canal!

This story sounds absolutely incredible, and yet to those who see one of the noble irrigation canals of Northern India for the first time, it is not only possible to mistake it for a river, but it is, in the case of the older canals, difficult to believe that the swift-flowing stream, full of life and energy, is wholly artificial.

To one acquainted with the canals of England, and indeed of Europe generally, the word recalls only a more or less stagnant ditch with a towpath at one side, an old cart horse plodding slowly and wearily along, dragging an elongated barge peopled by folk uncouth in speech and lazy of habit. The canal itself may be useful as a commercial highway, a cheap method of inland transit, but it presents a picture of all that is essentially inert and sluggish, and except to schoolboys in hard winters, when it is frozen and affords glorious skating for miles, it cannot evoke enthusiasm even in the most ardent admirer of rural simplicity.

But a canal in Northern India is very different, a thing of vital vigour, taking its rise in the great rivers that bring from the eternal snows the treasures of the deep which, as the Psalmist says, are laid up in storehouses—viz., the glaciers of the Himalayas. Down the waters roll in a current that by and by will be spread out over the length and breadth of the country, carrying with them wherever they go new life in the

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TRANSCRIPT.

ON AN INDIAN CANAL.

By MAJOR-GENERAL G. K. SCOTT-MONCRIEFF, C.B., C.I.E.

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A STORY was current in the Punjab a few years ago that a young and zealous district officer, who had just been transferred to the province from some other place, and had made his first cold-weather tour of his new territory, reported that he had in the course of his wanderings come across a broad and majestic river. He further stated that this river was not marked on any of the survey maps in his possession, and, improving the occasion, he took the opportunity to criticize in scathing periods the administration of Government departments (other than the covenanted civil service) in general, and the shortcomings of the Survey of India in particular. The story goes on to say that the report of this officer, after passing through the usual channels of correspondence, eventually found its way to Simla, that there it passed about from one branch to another until it was ultimately answered, and the zealous officer in question was informed that, from circumstantial evidence, it appeared that he must have discovered the Sirhind Canal!

This story sounds absolutely incredible, and yet to those who see one of the noble irrigation canals of Northern India for the first time, it is not only possible to mistake it for a river, but it is, in the case of the older canals, difficult to believe that the swift-flowing stream, full of life and energy, is wholly artificial.

To one acquainted with the canals of England, and indeed of Europe generally, the word recalls only a more or less stagnant ditch with a towpath at one side, an old cart horse plodding slowly and wearily along, dragging an elongated barge peopled by folk uncouth in speech and lazy of habit. The canal itself may be useful as a commercial highway, a cheap method of inland transit, but it presents a picture of all that is essentially inert and sluggish, and except to schoolboys in hard winters, when it is frozen and affords glorious skating for miles, it cannot evoke enthusiasm even in the most ardent admirer of rural simplicity.

But a canal in Northern India is very different, a thing of vital vigour, taking its rise in the great rivers that bring from the eternal snows the treasures of the deep which, as the Psalmist says, are laid up in storehouses—viz., the glaciers of the Himalayas. Down the waters roll in a current that by and by will be spread out over the length and breadth of the country, carrying with them wherever they go new life in the

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shape of corn and fruit, seed for the sower and bread for the eater. A navigation canal is merely a waterway between two places; an irrigation canal takes into its broad influence the whole of a countryside. It is an artificial river; only, unlike a natural river, it spreads out into innumerable branches as it progresses instead of gathering tributaries into its embrace.

To understand this, take the leaf of any tree you like—an oak or a sycamore,—or even a humble cabbage. Nature has worked out in countless variety—and every spring the miracle is repeated in millions of different ways in every forest—the perfect irrigation system which human engineers endeavour to imitate with only partial success. There is the stalk of the leaf—the main line of the canal. Then at the leaf itself we arrive at the irrigated area. In some cases (as in the oak) the main channel continues along the main axis, sending distributaries right and left. Or in other cases (as in a vine) there is a bifurcation into branch canals as soon as the irrigation begins, and these again into major and minor channels until the whole area partakes of the moisture from the parent tree, returning it as we know in the form of valuable material, worked in nature's wonderful laboratory, to build up the vigour and strength of the plant as a whole. So in our irrigation channels. They are dissipated over the surface of the land, first in the form of branches, then in distributaries (some of these carrying water enough to supply a city as big as Glasgow or Birmingham), then again in "village minors," and finally in little water courses which lead to the fields of wheat or maize or rice, and return to the parent state which has provided the means of nourishment, vigour and strength in the fruits of harvest and in the vigorous tillers of the soil.

Some of the older canals, too, are exquisitely beautiful. The Ganges Canal, for instance, issues from the parent stream at Hardwar, where white temples cluster at the base of low-wooded hills on the banks of a noble river, with swirling rapids and pools of clear blue water, reflecting on their surface the far-distant snowy peaks of the Himalayas against the deep cloudless blue of an Eastern sky. Here a weir has curbed the river, causing part of the water to flow down a new channel, forming a stream about 50 yards wide, about 10 ft. deep, and with a current so strong that no man can swim against it. Just below the entrance into this new channel there is a bridge of several arches under which the water rushes, eddying in whirlpools behind the piers, and if your eyes are good you will see gliding in and out of these eddies the noble ***mahseer***, the Indian salmon (so called, though the fish is of a different genus), olive-backed and orange-finned, and a glorious fighter. Spin a minnow or a spoon in the current and you will probably hook him, but see that you have plenty of line and the best of tackle, for your rod will bend into a perilous curve, and your reel will scream with the music that brings a thrill to the angler's heart, and your gallant fish, with that current in his favour, will be far out over the rushing water before you can bring any pressure to bear on him. There is a shingle bank about a hundred yards down where you may hope to land him, but if he takes you beyond that, as well he may, you will have many an anxious moment before you gaff him. When that proud achievement has been accomplished,

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you will be ready to declare that an Indian canal is first cousin to a Scotch salmon river.

For the next 17 or 18 miles of its course that canal is a thing of beauty, an engineering triumph, a sportsman's paradise. It winds along between wooded banks, a grassy road on either side, following the base of hills where every sort of game that man desires to shoot, from an elephant to a snipe, can be found by those who know where to seek it. Elephants, by the way, are preserved by the State, and a herd of them is not a thing which the sportsman desires to meet, for he cannot shoot them, and they are distinctly dangerous. But there are tigers and leopards, deer of many kinds, jungle fowl, partridges, ground game, geese and ducks of varieties and beauty too numerous to mention, so that the man behind the gun is hard to please if he cannot get what he wants.

Then in the open ground on the borders of the forest region the "grim grey boar" has his well-known haunts, and the sport he gives is about the most exciting in the world. A good start from a covert at home on a hunting morning in a grass country, when hounds are running hard and the hunter between your knees is going well up to his bit, perhaps catching hold of you a little at his fences, is delightful, but it does not touch the keen excitement of a race for first spear after the mighty boar. The ground one gallops over is such that in cold blood one would not attempt to ride there at the slowest pace, and how one's gallant steed manages to keep on his legs is a marvel. Hurtling through grass and bushes in front is the grey back of the old boar, champing his jaws viciously, and ready at any moment to jink out of the way or wheel suddenly, and with a grunt charge like lightning. It is indeed a royal sport.

Within a radius of a few miles of one of the inspection-bungalows, which occur at intervals of about 10 miles along the main line of the canal, all these sports can be enjoyed; but it may be doubted whether the band of soldiers who, in the early days of Queen Victoria's reign, engineered the Ganges Canal, can have had much time for such amusement. For they must have had plenty to do in the designing and executing of the many engineering masterpieces which abound in the first 17 miles of the main canal. In addition to bridges which span the stream at regular intervals, there are at least two "super passages," where the canal is crossed by mountain torrents from the hills, and where in the rainy season one may see the extraordinary sight of one stream crossing another at right angles, the natural torrent above and the canal below. Then there are artificial falls, dear to the angler, where the canal bed has to pass from a higher to a lower level; and one place where, by a cunning arrangement of gates and sluices, the waters of a hill-torrent pass through the new canal, and escape down their old accustomed channel. But the mightiest work of all is the Solani Aqueduct, where the canal crosses a valley about three miles in width, and there, not only in the rainy season but at all times, one may see the swift stream of the canal above and the Solani River flowing peacefully below. All these great works were carried out between 1846 and 1854, at a time when there were no railways in the country, and when the resources of modern machinery and other adjuncts to engineering works were unat-

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tainable. The chief engineer was Sir Proby Cautley, an artillery officer. He and his lieutenants had to devise their great works entirely from local resources, and they certainly succeeded in producing a monumental work which has aroused the admiration of all who have ever seen it. A young civil officer, who has since risen to be the lieutenant-governor of a province, said to me, years ago, "I would sooner have been the man who engineered the Ganges Canal than the greatest Governor-General that ever ruled India: the work of the civil governor passes away and leaves no trace, the work of the other benefits every generation who comes after him."

It was not only Englishmen who carried out work of this description. When the British first took over Northern India, a century ago, they found a canal on the western side of the Jumna, which traversed the country to the west of Delhi, and had fertilized an otherwise scantily productive region. This canal, now called the Western Jumna Canal, was originally made by the Emperor Tuglak Shah somewhere about the 14th century A.D., to convey water to a sporting property which he had at Hissar, on the edge of the great Indian desert. In the time of Akbar (about 1580 A.D.) this canal, which had fallen into disrepair, was improved, and early in the 17th century the Emperor Shah Jehan made a branch of it, which still exists, to his new capital at Delhi. The engineer of this great work was one Ali Mardan Khan, a name that deserves to be ranked with that of Cautley, Cotton, and many others as a pioneer of this branch of engineering.

There are some exquisite stretches of scenery on the branches of this canal. Tall shady trees stretch their boughs across its waters, and troops of monkeys swing their way across from one side to the other. Birds of every variety of colour—scarlet finches, bronze-green bee-eaters, flocks of chattering green parrots, and turquoise-blue kingfishers—delight the eye at every turn. There are quaint old bridges built of old-fashioned red bricks, with pointed arches and thick piers, which tell of their origin from purely Oriental ideals. The country, however, has in the past found the canal not an unmixed blessing. It was taken across the main lines of drainage of the country in such a way as to produce swamps that were haunts of waterfowl and snipe, but also nurseries of malaria. The British cantonment of Karnal, built in the early years of the 19th century, and at that time one of our most important frontier stations, became such a hotbed of fever that it had to be abandoned early in the forties, and the materials were taken away, as far as practicable, to be used in the building of the modern cantonment of Umballa Now almost the only traces of the former station are three huge cemeteries, full of fast-crumbling tombstones to the memory of British officers and men, their wives and children, who died there between 1820 and 1843.

The natives of the country, however, still remained; for although one might move a regiment or even a barrack, it is impossible to uproot the villages and their inhabitants, who were just as liable to malaria as the white men. So the rearrangement of the canal had to take place, and after infinite care and skill was carried out. The snipe and ducks have sought other haunts, but the people are now healthy.

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It seems impertinent and presumptuous to say that the great engineers of the past did imperfect work, and yet it would be no more an accusation or a disparagement than to say that George Stephenson's "Puffing Billy" was an inferior engine to a modern Great Northern express locomotive. Science has advanced in many directions during the past half-century, and in the intricate matter of the flow of water in channels there has been perhaps as much discovery as in any other branch.

About the time that Shah Jehan was planning his canal into Delhi, the great Galileo was making patient observations at Florence, where the floods of the Arno were giving much anxiety to the municipal dignitaries of that fair city. Galileo made some discoveries regarding the relations between the velocity of a stream and its longitudinal slope, which are at the foundation of our science to-day, and if he had lived longer, or perhaps been able to devote his whole mind to this subject, he might have gone a little further, and discovered the relations of the form of the cross section and the nature of the river-bed to that velocity. But he passed away, and as often happens the science got into the hands of purely doctrinaire professors, who, relying on mathematics only, built up theories which were based on imperfect observation. These heresies were accepted in one form or another for more than two centuries after Galileo had passed away. It was not until the latter half of the 19th century, at the time when Sir Proby Cautley and his able assistants were completing their great work in India, that a French engineer, M. D'Arcy, began a series of patient experiments in Paris that gave the clue to a genuine unlocking of Nature's secrets in this matter.

Nowadays we know that (owing to the imperfect knowledge that then prevailed) the Ganges Canal is made with too steep a longitudinal slope. "Steep" is a curious adjective perhaps to apply to a gradient of a foot and a-half in a mile, but the result is that the waters flow with too great a velocity, and for that volume of water even a foot in a mile would be too great. Then, again, if the Ganges Canal had been designed nowadays it is doubtful whether all the splendid works near the head would have been required at all. The length of the main line—the stalk of the leaf—would have been much shorter, and we should have lost all the charming scenery and variety of the first 17 miles or more. We live in a utilitarian age.

The actual work of distributing the waters all over the face of the land is in the hands of the irrigation engineers, although it might be said that the work involves not so much engineering as knowledge of law, of agriculture, and of the social life and economic conditions of the people,—knowledge which is essentially the province of the officers of the Civil Service. If, however, canal administration were to be committed entirely to the civil officers, their numbers would have to be largely increased (and it must be remembered that they are the most highly-paid officials in the country), and they would require every now and then technical advice, so that one could not reduce the engineer establishment very much.

The Indian peasant farmer lives in a village with others of his fellows, each village having its own petty government and its own clearly

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defined land, the landmarks of the fields being the same from ancient times, and all duly registered and assessed in the records of the State.

Formerly the village community was left to make its own water channels from the irrigation distributaries, but this led to so much wrangling and general iniquity that now the State does all that part of the work, leaving the outlets to be paid for by the beneficiaries. In Italy and South France, where irrigation is carried out on a comparatively small scale, but very systematically and well, the farmer pays for the actual water that he uses, measured by means of various ingenious devices. The water there is managed by a public trust, and it is considered as low a trick to take water out of one's turn as it would be to steal a neighbour's ox or his ass or anything that is his. Public opinion would soon make the delinquent's life a burden to him.

Unfortunately no such sense of honour prevails in the Orient. Water is paid for, therefore, indirectly—*i.e.*, the State undertakes to give the farmer as much water as is necessary for the maturing of his crop, and the farmer in return has to pay an enhanced revenue at so much per acre according to the crop, some requiring more water than others. The fundamental principle is that the farmer as tenant pays to the State as landlord a proportion of the yield of the land, or a sum equivalent to that proportion. If the crop should fail, if there is a visitation of locusts, or blight, or any other disastrous and unforeseen calamity, the State undertakes to remit the revenue, wholly or in part; while, on the other hand, there is a law which provides adequate punishment for unauthorized irrigation, or waste of water, or other misbehaviour.

The lowest actual agent of this administration is a functionary called a *patwàri*. He is a person of some technical knowledge, and before appointment he has to pass an examination in reading and making village maps, in measuring ground, and in estimating roughly the areas of land, in calculating the discharge (in cubic feet per second) of a water-course, and in keeping the accounts of areas irrigated in a village. Now although the pay of such a functionary is very small, and his work is considerable,—for he is responsible for the administration of affairs in at least half-a-dozen villages,—yet there is always a number of applicants for every vacant post. From which it is evident that the income of a *patwàri* is derived, like that of a steward on board a P. and O. steamer, not so much from his pay as from his "perks." What and how much these are, no white man probably has ever discovered; but before a white man can attempt to prevent it, he must cease to countenance the tipping of railway porters and gamekeepers, or even of housemaids. Where, however, the danger lies is in the corruption that takes away the water from the poor man and gives it to the rich. That may be reduced to a minimum by constant supervision.

A friend of mine was much amused once to see how the principle of *backshish* worked in a huge fire in a native city. The fire brigade turned out, there was plenty of water, and soon a stream was hissing on the burning buildings, without much result. There were, however, certain shops somewhere in the vicinity which, being at some little distance, the fire had as yet not touched. First one shopkeeper approached the fireman, and giving him a few rupees asked him to direct his stream of

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water on the donor's shop. This was promptly done, the burning building being left to itself. Then another shopkeeper came, gave more rupees, and the stream consequently went to *his* shop. And so on, until many shops had been drenched and many rupees passed to the fireman. And in course of time the fire burnt out, and everybody went home quite satisfied, except the owner of the burnt house, who regarded the calamity as an inexorable fate.

I am not in the least defending the corruption of the Oriental, but it is a ridiculous hypocrisy which assumes that it does not exist, and that a system so ingrained in the customs of the people can be eradicated all at once.

The outward and visible sign of a *patwàri* is a yellow turban. It is useful to be able to recognize these and other functionaries of the irrigation department at a glance, and as a uniform is out of the question, the colour of the head-dress is a simple solution of the matter. There are certain men whose duty is to patrol the banks and do petty repairs, whose distinctive head-dress is bright orange, visible from afar, so that the English officer who has detected something wrong—a rat-hole in a bank or an accumulation of weeds at an outlet—can descry one of these guardians of maintenance from a distance by the brilliant colour of his headgear. But this very brilliancy has its little drawbacks. There was once a superintending engineer, with an irascible temper and an indifferent seat on horseback, who found the startling colour a trial to his horse's nerves and his own equilibrium. Consequently the unfortunate wearers of the obnoxious colours were greeted by him with such execrations that they, poor men, perhaps from a guilty conscience, imagined that their misdeeds had been found out and that the more they avoided the great man the better. One of them one day was coming round a bend in a canal when, to his horror, he met the superintending engineer and his retinue riding towards him Escape was useless, so he hid behind a bush. But as the sahib was just passing, the instinct of politeness was too strong for him, and he suddenly shot out of his place of concealment with an aggressive but obsequious salutation. Naturally the horse shied most violently, nearly throwing his rider into the canal. Language was inadequate to express the wrath of the great man, who, not unnaturally, imagined that he was the victim of a diabolical plot ; but long before he could recover his seat and thunder forth his wrath, the luckless offender had fled in terror, with the now loosened orange head-dress streaming behind him as he raced headlong from the scene of his wickedness.

The executive engineer of a running canal has to be continually travelling about his district. To enable him to do so in some degree of comfort, and indeed to make it possible for him to do so at all, there are little inspection houses dotted about at intervals of 10 or 12 miles. Some of these are charming little places. A whitewashed bungalow, surrounded by a cool, arched verandah, and often adorned with lovely flowers, with a flat roof, on which one may sleep in comparative coolness even on the hottest night, with the starry canopy overhead, is situated in a garden with orange and banana and loquat bushes and trees that afford a grateful shade. The canal is close at hand, and one hears the

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murmur of the water. Inside, the house is plainly but sufficiently furnished, and usually there are a few books to lighten official cares. Often have I found in such places old volumes of "Maga," and no more charming intellectual feast could one desire,—a veritable refreshment after a day spent in the endeavour to unravel some of the tangled skeins of Eastern intrigue.

For an irrigation engineer's life is a strenuous one. Very early in the morning he has to be out and away. In the bracing sharp air of the cold season this is invigorating and delicious, but in the middle of June or July, when the hot winds are blowing and all nature is clamouring for water, when the ground is like iron and the heavens like brass, it takes some effort to rise before dawn and swing into the saddle. It must be done, however, for there is much to supervise. Some new improvements devised since last inspection, some engagement to meet a complainant, some endeavour to settle on the spot disputes between rival parties both clamouring for what they think their rights, and, above all, the unexpected visits to outlying places where waste of water or unauthorized use thereof may occur, and where the *patwàri* may imagine he can carry out his own little plans without interference. All this will take several hours of travel on horseback, usually in the company of a *zilladar*, a native subordinate, who is the superintendent of about a dozen or more *patwàris*, generally a man of good family and education, and, as far as my experience goes, always a well-informed man much interested in his work.

By the time the sun has risen high in the heavens, and all nature is beginning to be hushed in the glare of the heat, the engineer has reached the next stage of his tour at the inspection house, to which in the meantime his baggage has preceded him. Native servants are so well accustomed to the routine of such travel that he will find everything ready for him, his office papers all laid out on his table, his breakfast ready to be served. A delicious bath, and possibly a short siesta, precedes his breakfast, or rather *déjeûner* (for it corresponds to the midday meal of continental Europe), and then follows some hours of steady office work. Later in the day the native secretary brings in a huge pile of papers written in the vernacular, and, squatting on the floor with his inkstand and reed pens, proceeds to read forth petitions, complaints, reports relating to the administration of the whole district. To these replies are briefly dictated, which the secretary writes on the papers and the officer initials. Persian handwriting is very difficult for an Englishman to read, and although every canal officer has to pass an examination in the reading of these petitions, it is comparatively rare that any ordinary man can read one offhand without assistance. Thus, one is obliged to depend very much on the honesty of the secretary, and it says a good deal for these men that one scarcely ever hears of a case where they deliberately wrote a false answer to a petition.

By the time this is over the day is far spent. Possibly our hard-worked officer may find a little time for relaxation, and if he is in a sporting neighbourhood he may get an hour's shooting before sunset. But it is not always so, and a short walk in the evening is about as much as most men can manage. Then dinner, and early to bed. The same routine

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follows next day, and practically every day. For a few days each month he may be at his headquarters, and may then see a few of his countrymen, men employed in various other branches of the public service; but for the most part an irrigation engineer's life is, so far as European society is concerned, a solitary one, and lived apart from domestic or social relaxation.

This solitude is perhaps not much felt when a man is in vigorous health, but in a life of much exposure there is the constant possibility of sickness, and with recurring attacks of fever or rheumatism the loneliness, and the consciousness that medical advice is far out of reach, may become a very heavy burden to the weary worker. Worse than fever or rheumatism, also, are the two dread spectres of Eastern life, "the pestilence that walketh in darkness and the destruction that wasteth at noonday"—cholera and sunstroke. There are few canal officers who have not at least a slight acquaintance with one or other, or both, of these grim destroyers, and there are many who, at some time of their career, have had to grapple with them at close quarters. Happy the man who can look such foes fair and square in the face with unflinching calmness. The result may be a somewhat weakened body, but the *man* is stronger and better ever afterwards.

A canal life, too, in spite of its solitariness, has its compensations to a man who is a naturalist, or in some places to a sportsman, and in rarer instances to the high-souled enthusiast who is imbued with the generous desire to benefit his fellow-men, and in some way help to ameliorate the lot of the poor.

Whole-hearted enthusiasts of this sort are, however, not always to be met. I knew such a man, who had spent twenty-five years of his life on this work, and, in spite of the loneliness, thoroughly enjoyed it, even though most of his time had been spent in very hot and trying parts. His whole soul was in his work,—not in the engineering part of it, for in that he took little interest, although he had passed high examinations. What he lived for was the helping of the people of the land by every possible means. He spoke their language perfectly—not merely the polished Urdu of the gentlefolks, but the rough *patois* of the peasant. What he did not know about their crops and their methods of cultivation was not worth knowing. They regarded him with intense admiration and affection, and he dealt with them with the most infinite patience, listening to their interminable yarns and quietly reasoning with them, settling their quarrels and helping them in their difficulties. But the effect on the man himself was curious. He had lived apart from his fellows so much that in many little matters he had become a law to himself. His clothes were cut in a fashion that suited him. His food was peculiar, and the times of his meals were at such hours as were most convenient to himself, not those of ordinary society. He took an interest, keen and intelligent, in all that was going on in the Western world, and he was a great reader; but he regarded all progress that did not directly bear on philanthropic schemes as of very small value. As for the mere politician, the M.P., the man of letters, the financier, the business man,—he regarded them with contemptuous pity. He was *the* influential authority in a district as large as a big English county,

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and as densely populated, and although there were other Englishmen in that district who were the responsible representatives of the ruling race, none of them was, or could be, brought into such daily contact with the people as he. And in this life-work he was supremely content.

A somewhat similar character must have been the great Sir Arthur Cotton. To the present generation, perhaps, it is necessary to state who he was, for when he died at a very advanced age, *The Times* obituary notice stated " he was employed by the Public Works Department in the making of roads, the construction of bridges, and other engineering works." These last words are truly delicious. The correspondent had apparently never heard that the veteran soldier had been one of the greatest engineers of his day, and had harnessed some of the mightiest rivers in Southern India—the Godavery in particular*—to the work and service of men, had by his skill transformed enormous tracts of country from barrenness to fertility, thereby rendering incalculable service to generations of his fellows. I had the privilege of hearing this great and good man lecture in 1874 at Chatham, on the work to which he had devoted so many years. The lecture was full of statistics which I fear had little interest for an audience composed chiefly of young Engineer officers, though I remember he made one rather remarkable prophecy. Talking of inland transit and the demands upon the Engineer to provide greater facilities for it, he said that the time would soon come when the bicycle, then the plaything of the few, would be the necessity of the many, and that working men would go to and from their work on these machines. It seemed a far-fetched idea then, but the speaker lived to see it fully accomplished. At the conclusion of his lecture the old man drew his tall, spare figure up to its full height and said—

" Gentlemen, my young brother officers, I envy you. Many of you are going to a distant country, to a life which, although it is an arduous one, is full of compensations. You will, if you are employed on irrigation work, find it in itself intensely interesting, and you will have the satisfaction of knowing that it is of infinite value to the people. You will thereby exert an influence on many who can never know you, but who will bless the unknown Englishman who has brought to them such advantages. What nobler career can any man desire ? "

* *Blackwood's Magazine*, June, 1897—" An Indian Romance: A Lesson of the Famine " ; May, 1900—" Value of the Water of the Great Rivers of India."

(*To be continued*).

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NOTICES OF MAGAZINES.

Revue Militaire Suisse.

December, 1913.

Operations of the 7th and 2nd Bulgarian Divisions during the First Balkan War.

By A.—This article is divided into two parts. The first contains a short account of the operations of these two divisions from the outbreak of war up to the end of November, 1912, during which period, while keeping touch with the Servians and Greeks to the west and the main Bulgarian forces to the east, they cleared the whole of the country north of the Ægean Sea, between the rivers Vardar and Maritza. It includes the capture of Salonika (claimed also by the Greeks) and of Dedeagatch, and the final overthrow of the Turkish Army of the Rhodope at Bedekli. The Turkish losses at the last named were Javer Pasha and his staff, 2 divisional generals, 265 officers, 10,000 R. & F., 2 mountain batteries, 2 mitrailleuses, 1,500 horses, and quantities of ammunition and stores.

The second part deals with the investment, siege, and capture of Adrianople. The strategic value of this capital of Thrace is considerable; situated as it is at the confluence of the Tunja and Arda with the Maritza, and commanding the railway, it is the key to the doors leading from Bulgaria to Constantinople and the Ægean and Marmora Seas. The defences of the city were in process of transformation at the commencement of the campaign, but in spite of their backward state were capable of offering considerable resistance. As a result of this, and of the energy of the commander, Chukri Pasha, large forces of the allies were immobilized for five months, during which period also the Bulgarians were deprived of the use of the railway for the conveyance of supplies. A short account of the salient incidents of the siege is given, and the question is asked as to what would have occurred had Kirk Kilisseh, commanding the second route into Thrace, been fortified as recommended by Marshal von der Goltz.

The Communications of the Grand Army in 1806–07.

When it became necessary to extend the Line of Communications beyond Bamberg, the choice of the central route through Schleiz was inevitable owing to its greater security than the flank routes, and also because Kronach lay on it and had been carefully organized as a *point d'appui*. After the victory of Jena (14th October) Weimar, Naumberg and Buttelstadt fell rapidly with their stores of horses, carts, flour, oats, etc. Erfurt did not fall until the 16th, and then became a valuable acquisition owing to the further supplies it contained, and

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murmur of the water. Inside, the house is plainly but sufficiently furnished, and usually there are a few books to lighten official cares. Often have I found in such places old volumes of "Maga," and no more charming intellectual feast could one desire,—a veritable refreshment after a day spent in the endeavour to unravel some of the tangled skeins of Eastern intrigue.

For an irrigation engineer's life is a strenuous one. Very early in the morning he has to be out and away. In the bracing sharp air of the cold season this is invigorating and delicious, but in the middle of June or July, when the hot winds are blowing and all nature is clamouring for water, when the ground is like iron and the heavens like brass, it takes some effort to rise before dawn and swing into the saddle. It must be done, however, for there is much to supervise. Some new improvements devised since last inspection, some engagement to meet a complainant, some endeavour to settle on the spot disputes between rival parties both clamouring for what they think their rights, and, above all, the unexpected visits to outlying places where waste of water or unauthorized use thereof may occur, and where the *patwàri* may imagine he can carry out his own little plans without interference. All this will take several hours of travel on horseback, usually in the company of a *zilladar*, a native subordinate, who is the superintendent of about a dozen or more *patwàris*, generally a man of good family and education, and, as far as my experience goes, always a well-informed man much interested in his work.

By the time the sun has risen high in the heavens, and all nature is beginning to be hushed in the glare of the heat, the engineer has reached the next stage of his tour at the inspection house, to which in the meantime his baggage has preceded him. Native servants are so well accustomed to the routine of such travel that he will find everything ready for him, his office papers all laid out on his table, his breakfast ready to be served. A delicious bath, and possibly a short siesta, precedes his breakfast, or rather *déjeûner* (for it corresponds to the midday meal of continental Europe), and then follows some hours of steady office work. Later in the day the native secretary brings in a huge pile of papers written in the vernacular, and, squatting on the floor with his inkstand and reed pens, proceeds to read forth petitions, complaints, reports relating to the administration of the whole district. To these replies are briefly dictated, which the secretary writes on the papers and the officer initials. Persian handwriting is very difficult for an Englishman to read, and although every canal officer has to pass an examination in the reading of these petitions, it is comparatively rare that any ordinary man can read one offhand without assistance. Thus, one is obliged to depend very much on the honesty of the secretary, and it says a good deal for these men that one scarcely ever hears of a case where they deliberately wrote a false answer to a petition.

By the time this is over the day is far spent. Possibly our hard-worked officer may find a little time for relaxation, and if he is in a sporting neighbourhood he may get an hour's shooting before sunset. But it is not always so, and a short walk in the evening is about as much as most men can manage. Then dinner, and early to bed. The same routine

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follows next day, and practically every day. For a few days each month he may be at his headquarters, and may then see a few of his countrymen, men employed in various other branches of the public service; but for the most part an irrigation engineer's life is, so far as European society is concerned, a solitary one, and lived apart from domestic or social relaxation.

This solitude is perhaps not much felt when a man is in vigorous health, but in a life of much exposure there is the constant possibility of sickness, and with recurring attacks of fever or rheumatism the loneliness, and the consciousness that medical advice is far out of reach, may become a very heavy burden to the weary worker. Worse than fever or rheumatism, also, are the two dread spectres of Eastern life, "the pestilence that walketh in darkness and the destruction that wasteth at noonday"—cholera and sunstroke. There are few canal officers who have not at least a slight acquaintance with one or other, or both, of these grim destroyers, and there are many who, at some time of their career, have had to grapple with them at close quarters. Happy the man who can look such foes fair and square in the face with unflinching calmness. The result may be a somewhat weakened body, but the *man* is stronger and better ever afterwards.

A canal life, too, in spite of its solitariness, has its compensations to a man who is a naturalist, or in some places to a sportsman, and in rarer instances to the high-souled enthusiast who is imbued with the generous desire to benefit his fellow-men, and in some way help to ameliorate the lot of the poor.

Whole-hearted enthusiasts of this sort are, however, not always to be met. I knew such a man, who had spent twenty-five years of his life on this work, and, in spite of the loneliness, thoroughly enjoyed it, even though most of his time had been spent in very hot and trying parts. His whole soul was in his work,—not in the engineering part of it, for in that he took little interest, although he had passed high examinations. What he lived for was the helping of the people of the land by every possible means. He spoke their language perfectly—not merely the polished Urdu of the gentlefolks, but the rough *patois* of the peasant. What he did not know about their crops and their methods of cultivation was not worth knowing. They regarded him with intense admiration and affection, and he dealt with them with the most infinite patience, listening to their interminable yarns and quietly reasoning with them, settling their quarrels and helping them in their difficulties. But the effect on the man himself was curious. He had lived apart from his fellows so much that in many little matters he had become a law to himself. His clothes were cut in a fashion that suited him. His food was peculiar, and the times of his meals were at such hours as were most convenient to himself, not those of ordinary society. He took an interest, keen and intelligent, in all that was going on in the Western world, and he was a great reader; but he regarded all progress that did not directly bear on philanthropic schemes as of very small value. As for the mere politician, the M.P., the man of letters, the financier, the business man,—he regarded them with contemptuous pity. He was *the* influential authority in a district as large as a big English county,

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and as densely populated, and although there were other Englishmen in that district who were the responsible representatives of the ruling race, none of them was, or could be, brought into such daily contact with the people as he. And in this life-work he was supremely content.

A somewhat similar character must have been the great Sir Arthur Cotton. To the present generation, perhaps, it is necessary to state who he was, for when he died at a very advanced age, *The Times* obituary notice stated " he was employed by the Public Works Department in the making of roads, the construction of bridges, and other engineering works." These last words are truly delicious. The correspondent had apparently never heard that the veteran soldier had been one of the greatest engineers of his day, and had harnessed some of the mightiest rivers in Southern India—the Godavery in particular*—to the work and service of men, had by his skill transformed enormous tracts of country from barrenness to fertility, thereby rendering incalculable service to generations of his fellows. I had the privilege of hearing this great and good man lecture in 1874 at Chatham, on the work to which he had devoted so many years. The lecture was full of statistics which I fear had little interest for an audience composed chiefly of young Engineer officers, though I remember he made one rather remarkable prophecy. Talking of inland transit and the demands upon the Engineer to provide greater facilities for it, he said that the time would soon come when the bicycle, then the plaything of the few, would be the necessity of the many, and that working men would go to and from their work on these machines. It seemed a far-fetched idea then, but the speaker lived to see it fully accomplished. At the conclusion of his lecture the old man drew his tall, spare figure up to its full height and said—

" Gentlemen, my young brother officers, I envy you. Many of you are going to a distant country, to a life which, although it is an arduous one, is full of compensations. You will, if you are employed on irrigation work, find it in itself intensely interesting, and you will have the satisfaction of knowing that it is of infinite value to the people. You will thereby exert an influence on many who can never know you, but who will bless the unknown Englishman who has brought to them such advantages. What nobler career can any man desire ? "

* *Blackwood's Magazine*, June, 1897—" An Indian Romance: A Lesson of the Famine " ; May, 1900—" Value of the Water of the Great Rivers of India."

(*To be continued*).

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NOTICES OF MAGAZINES.

Revue Militaire Suisse.

December, 1913.

Operations of the 7th and 2nd Bulgarian Divisions during the First Balkan War.

By A.—This article is divided into two parts. The first contains a short account of the operations of these two divisions from the outbreak of war up to the end of November, 1912, during which period, while keeping touch with the Servians and Greeks to the west and the main Bulgarian forces to the east, they cleared the whole of the country north of the Ægean Sea, between the rivers Vardar and Maritza. It includes the capture of Salonika (claimed also by the Greeks) and of Dedeagatch, and the final overthrow of the Turkish Army of the Rhodope at Bedekli. The Turkish losses at the last named were Javer Pasha and his staff, 2 divisional generals, 265 officers, 10,000 R. & F., 2 mountain batteries, 2 mitrailleuses, 1,500 horses, and quantities of ammunition and stores.

The second part deals with the investment, siege, and capture of Adrianople. The strategic value of this capital of Thrace is considerable; situated as it is at the confluence of the Tunja and Arda with the Maritza, and commanding the railway, it is the key to the doors leading from Bulgaria to Constantinople and the Ægean and Marmora Seas. The defences of the city were in process of transformation at the commencement of the campaign, but in spite of their backward state were capable of offering considerable resistance. As a result of this, and of the energy of the commander, Chukri Pasha, large forces of the allies were immobilized for five months, during which period also the Bulgarians were deprived of the use of the railway for the conveyance of supplies. A short account of the salient incidents of the siege is given, and the question is asked as to what would have occurred had Kirk Kilisseh, commanding the second route into Thrace, been fortified as recommended by Marshal von der Goltz.

The Communications of the Grand Army in 1806–07.

When it became necessary to extend the Line of Communications beyond Bamberg, the choice of the central route through Schleiz was inevitable owing to its greater security than the flank routes, and also because Kronach lay on it and had been carefully organized as a *point d'appui*. After the victory of Jena (14th October) Weimar, Naumberg and Buttelstadt fell rapidly with their stores of horses, carts, flour, oats, etc. Erfurt did not fall until the 16th, and then became a valuable acquisition owing to the further supplies it contained, and

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ovens capable of baking 25,000 bread rations daily. By the 20th this strong citadel was organized as a post on the line of communications. However on the 17th a column of prisoners, escorted by three companies and a few cavalry, was ambushed between Gotha and Eisenach and all the prisoners liberated. After this Napoleon was obliged to detail four regiments of the line and three of dragoons to the L. of C. The enemy's troops in Hesse had retreated after the 14th, and the circuitous line of communications was changed to Mayence-Fulda-Erfurt by Army Order of 18th.

IX. *Notes on Material and Various Services.*—The artillery consisted of 3, 4 and 8-pr. field guns, 6-in. and 8-in. mortars, 12-pr. guns and 16 and 24-pr. siege guns. The artillery commander complained of the variety of calibres and consequent complication of the ammunition supply. To these, however, must be added captured weapons. Some particulars of the composition of the Corps and Army Parks are given.

The medical services left much to be desired, frequently some of the surgeons were only engaged for the campaign. The administration of the hospitals was entrusted to a Board of Directors, whose probity was not above suspicion.

The postal service was practically non-existent.

The troops were badly clothed and shod. After Jena all conquered towns were requisitioned for materials, but owing to haste the workmanship was poor.

Transport was carried out by contract with Government horses and harness, but the result was unsatisfactory as no one firm had sufficient capital. If Napoleon had not shrunk from the expense he would soon have given up this system.

The supply accounts, preparation, and distribution were confided to three Boards.

X. *Summary.*—The Grand Army was an unsurpassed military instrument, whose power lay in the prodigious knowledge and genius of its chief, in its warlike experience, and in the spirit of its soldiers. Organization of the departmental services had little influence on the results obtained. Instead of this, success in battle was the great remedy. However, Napoleon's organization of his communications was sound, and is still worthy of study. If the results did not always fulfil his expectations it was due to material difficulties impossible to overcome at that date. Means of transport were meagre—carts and a few waterways—distances were considerable, atmospheric conditions were of great moment, and there was no arsenal capable of supplying all an army's needs. The Emperor was thus led to utilizing local resources, the endurance of the troops and civil population, less used to comfort, less luxurious and less educated than at the present day, allowed of reducing transport to a minimum and even of omitting the provision for the sick and wounded and of the Post Office. In our day the large numbers in the field, the complicated weapons, and the greater necessities of the troops, make the utilization of local resources difficult, and render essential the forwarding of supplies from the rear. On the other hand telegraphs, railways and motors facilitate these services. The difficulty is not so much the quantity to be transported, but the vulnerability of the extended line.

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The Battle of Cressier.

This article is concluded with the account of the assault of the position. It is noteworthy that each man of the troops detailed for the decisive attack carried a sandbag, half filled in the firing line, filled in the reserve who marched with rifles slung. The advance was made by night, and fire trenches excavated under cover of the half-filled sandbags, supplemented by earth from the filled sandbags passed up by the reserve. The bags were again and again passed to the rear to be filled, in order to hasten the provision of bullet-proof cover for the firing line in the shortest possible time. The supports also entrenched themselves, the reserve utilized existing cover. Meanwhile sappers were sent on, rolling gabions or barrels filled with earth in front of them, to make practicable breaches in the obstacles, which entrenched scouts prevented the enemy from closing again. The attack was made soon after daylight, preceded by heavy artillery fire, and was successful. The defence had, however, fulfilled its object, and reinforcements came up in time to check any further advance of the attackers.

A.R.R.

Rivista di Artiglieria e Genio.

October, 1913.

Under the heading of "Tactical Lessons of the War in the Balkans," a valuable article by Lieut.-General von Reichenau appears in the *Militär-Wochenblatt* of the 30th September, 1913. The following extracts are taken from it as showing some of the lessons to be learnt from the campaign:—According to verbal reports of competent persons who took part in the war, various incidents connected both with field warfare and with selected position confirmed the teachings of previous wars, and accentuated the evolution taking place in certain tactical requirements.

Facts have especially shown that the artillery now dominates the combat. Throughout the war in the Balkans, the infantry was unable to undertake offensive action of any importance or to resist tenaciously in the defensive without the continuous support of the artillery. Hence the tendency to establish constant co-operation between the two arms. Although this principle between the infantry and artillery is insisted upon in the regulations of all armies, it is only partially applied in peace times, as the infantry constantly undertakes unaided, attacks which, as the war in the Balkans shows, would certainly prove ineffectual owing to the enormous losses which would be incurred at the start.

Infantry attacks on a large scale by day have become exceptional, and they seldom succeed in keeping under the fire of the defence sufficiently to allow of a successful result. The attacker is therefore driven to rely greatly on night operations. The fact that in these night attacks the bayonet was generally preferred, may be attributed both to

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the naturally impulsive character of the combatants, to the difficulty of aiming the rifle, and the want of confidence in its efficacy.

Judging by this last war, writes then General von Reichenau, the question may be asked whether the old aphorism of Suwaroff "la pallotola è stolta, la bayonetta e saggia"—"the bullet is foolish, the bayonet is wise"—may not still hold good; and without doubt it may do so in the hands of men who do not properly understand the use of their rifles, but who are acquainted with the value of the bayonet and use it energetically. But in the case of a firearm in the hands of a competent man the medal is reversed, and the dicta of Frederick the Great and Napoleon are verified. Whilst Frederick in the first period of his great career gave only a restricted importance to firearms, his opinions changed—the result of experience. In fact the great King in his military testament declared that battles were won by a superiority of fire in the case of a decisive attack. Napoleon, too, pronounced in a manner more precise, "Le feu est tout, le reste est peu de chose." When it is considered that these fundamental maxims, derived from rich experience of wars, were delivered in times when firearms were primitive as contrasted with those of the present day, it is reasonable to attribute exceptional value to them. But, in spite of all this, there is a strong opinion in favour of the bayonet, based on the experience gained in the Russo-Japanese War and the wars in the Balkans. An appreciation of the efficacy of weapons can only be correct when account is taken both of the quality of the troops and of the general tactical situation, and it should be remembered that both in the Far East and also in the Balkans, one of the belligerents remained essentially and constantly on the defensive, a circumstance that explains the superiority of the other side in matters of strategy, tactics and *morale*.

The superiority of the attack allowed of methods of fighting which under other conditions would not have been successful. The Japanese, and in a measure the Bulgarians, obtained successes mainly through the ill-aimed fire of their adversaries, which the Austrians, confronted by the needle-gun, and the English, face to face with the well-aimed fire of the Boers, were unable to obtain. If, in spite of the deficient intuition of the Turkish troops—among the rank and file of whom there were men who in peace time had never fired a shot—the Bulgarians suffered enormous losses in their attacks, it is fairly evident that they would have failed in front of an enemy proficient in musketry. The lesson, then, that we learn from the recent events of the war is not the value of a skilful use of the bayonet, but that troops should be instructed in making efficient use of their rifles, and in placing full confidence in those weapons. And this is a warning that should be seriously taken to heart to ensure efficient preparation for war.

Hundreds of millions are expended on modern armaments, and it is only right therefore that musketry instruction should be efficient. Not only is it necessary to explain to the soldier what a powerful weapon he possesses in the modern rifle, but also that he should learn how to make the best use of it. Instruction which does not give such results is deficient. A weapon of small value in skilful hands is better than a perfect arm badly used. If the infantry soldier places full confidence

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in his weapon—confidence that has been inculcated by instruction—and is supplied with sufficient ammunition, he has nothing to fear from the bayonet.

Endurance on the march and skilful marksmanship are together the qualities that form the characteristics of good infantry. Artillery and infantry are more closely linked together than was formerly the case, and in the lines of combat they should always be grouped together if possible. The need of directing and timing the fire gives the commandants of detachments, and especially to the commandants of batteries, ample scope for selecting targets and for timing the opening of fire. Besides, against momentary targets, only the most rapid fire can produce any useful effect.

In the application of trenches, especially in the offensive, the Bulgarians showed considerable skill. They frequently made use of three lines of trenches for riflemen, placed one above the other, which were out of view of their opponents until the moment of opening fire.

In the lines of Citalja, the Turks excavated trenches of such width and depth that they were able to move their guns and mortars under cover. In conclusion ; " Cover, cover, and always cover."

Whilst all artillery during the last decade has increased its ammunition supply in accordance with the tendency of modern tactics, the measures taken are still far from providing for the exigencies of modern warfare. The deceased General Langlois considered a supply of 3,000 rounds per piece to be indispensable. Considerations should also be given to the newly established arrangements for assuring an adequate reserve supply of ammunition on the battlefield. In the Balkan War, sending fresh supplies of ammunition to the firing line by means of ammunition wagons under fire from the enemy's artillery caused enormous losses ; so much so that they had to resort to carrying the ammunition on men's shoulders, or by beasts of burden. But even in the Balkans—although the roads were in a wretched condition—good results were obtained by convoys of motor cars to transport the ammunition from the depôts in rear.

An important lesson may be learnt from the insufficient mobility of the field artillery which was too heavy for rapid offensive movements.

With regard to mobility, there seems to be a tendency in some armies to utilize the mountain guns for field artillery. This, however, would seem to be a retrograde step, as mountain guns can never be completely substituted for field guns. Although firing against aeroplanes is now one of the most important problems engaging the attention of all countries, there seems to have been few opportunities of learning anything on the question during the Balkan War.

The above considerations refer to the principal lessons that are to be learnt from the war in the Balkans. With regard to the attack and defence of fortified places there is not much to learn, possibly because the besieged places were of an antiquated type, or because the artillery material employed by the besiegers, as well as by the defenders, was far below the standard which is now to be found in the siege parks of all the great armies. The war in the Balkans has given a new impulse to the solution of various questions of a tactical and technical character, viz. :—(1), To acquire a field gun with a projectile that can be used equally

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against a land or an aerial target ; (2), to modify the shells of field guns so as to make them efficient against aerial objects ; (3), to increase the supply of ammunition both for guns and mortars ; (4), to ensure by new methods a constant supply of ammunition to batteries in action ; (5), to find means for improving the fire against momentary targets ; (6), to adopt the increased necessity for cover to the greatest possible efficacy of fire ; (7), to establish more efficient methods of fire against masked targets, and cover, by means of aeroplanes for reconnoitring and observation ; (8), to inspire the infantry with greater confidence in their weapon ; (9), to acquire tactical formations of a less vulnerable kind for manœuvres and for war, in relation to the increased efficacy of fire ; (10), to link more closely the relations between the infantry and the artillery especially in the attack.

E. T. THACKERAY.

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CORRESPONDENCE.

MASONRY ARCHES AND MECHANICAL TRANSPORT.

SIR,

Now that heavy mechanical transport has been provided for a large number of the Army Service Corps units of the Army, a task that a R.E. officer on service will probably often have to undertake in the future, will be the reconnaissance of a certain number of miles of some country road, with a view to ascertaining whether the various bridges and culverts are strong enough to carry the heavy mechanical transport vehicles, and he will also have to prepare schemes for strengthening them, if necessary.

In the case of timber, steel, or flat ferro-concrete bridges, no great difficulty presents itself, as the new *Instruction in Military Engineering*, Part III. (*a*), gives tables showing the maximum bending moments produced by these vehicles on various spans. But the bridges most commonly met with on rural roads are of the arched-masonry type, and, if he encounters one of this type, the average R.E. officer will probably find himself out of his depth at once.

Although the general principles of such structures are taught to the recently-joined officer during his construction courses at the S.M.E., comparatively few R.E. officers have practical experience in the design and construction of them. The average D.O. uses steel joists, or ferro-concrete beams to span a gap, and the officers who do know a good deal about masonry arches, are generally those who have specialized in civil engineering, and have gained their experience while employed in Public Works Departments in India or elsewhere. Such officers do not, as a rule, come back to the field units of the Corps.

The reconnaissance described above would therefore have to be carried out by some officer whose knowledge of masonry arches is confined to what he learned at the S.M.E. His only official guide on the subject is the *Manual of Masonry Structures*.

Now in this Manual, on p. 107, *et seq.*, will be found the following remarks with regard to external rolling loads on arched bridges :—

" In dealing with the design of an arch ring that has to stand a rolling load, there is the difficulty of determining the effect of the weight of that rolling load, and what to allow for it.

" A convenient graphic way of obtaining this is to draw what is called a load contour . . ."

" In dealing with rolling loads the weight to be considered for ordinary vehicular traffic is very small.

" If it can be ensured that the arch ring is thoroughly strong and will be able to carry the dead load, the chances are that the small additional

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stress caused by the moving load will be met by a very slight addition to the thickness of the arch ring.

" Practically a design is made for the dead load, and, as an approximation, a small percentage added for occasional and moving loads deduced by a rough comparison of equivalent weights.

" In the case of a very heavy rolling load, it is only when such loads are over the centre of the span, or very close to it, that the stress can be anything like accurately calculated.

" It is not possible to determine exactly what is the effect or influence that occasional and rolling loads exert upon an arch ring."

Again on p. 96 :—

" The calculations in connection with the stability of arch rings are somewhat involved, but by using a simple graphic method, the desired result may be obtained by a series of approximations."

" A segmental or semicircular arch tends to fall by sinking at the crown, and rising at the haunches.

" A pointed arch tends to fail by rising at the crown and falling at the haunches.

" A straight arch tends to fail by the voussoirs sliding vertically down."

It will be seen, from the above extracts, that the investigations as to whether a particular design is strong enough to carry its own dead load, involve either somewhat abstruse mathematics or approximate graphic solutions, or reliance on standardized dimensions that have been found suitable in the past, and can be found in engineering pocket-books. The far more complicated problem of rolling external loads was avoided by the original designs of country bridges owing to the fact that the ordinary vehicular traffic produced stresses that were small in comparison with the dead load of the bridge.

If it could be said that the A.S.C. motor vehicles came under the heading of ordinary vehicular traffic, the examination by the R.E. officer could be confined to seeing whether the joints in the arch ring were sound, or whether there was decay in the masonry.

But it is extremely doubtful whether the original designer had in his mind external loads anything like so heavy as those produced by the A.S.C. vehicles.

Now, if the calculations for the ordinary dead load are so abstruse and indefinite and the distortions due to overloading so peculiar, those for heavy rolling loads must be very much more so. Obviously they would be quite beyond the powers of an officer on service, working against time, and equipped with neither drawing instruments nor mathematical text books. A knowledge of the axle loads of the commercial vehicles, if any, used in the district, would help him, but they might very likely not be obtainable.

What appears to be wanted are some rough rules of thumb, based on measurements that the officer can take, *i.e.* the span, rise, thickness of arch ring, and depth of filling, to enable him to decide whether or not the weights of the vehicles he has to consider, may be taken as ordinary vehicular traffic in comparison with the dead load of the bridge, and further—in the case of the larger spans, and flatter arches, where it will probably be necessary to introduce additional supports,

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the kind of distortion which is likely to take place, and the direction and amount of the extra stresses that would have to be provided for.

Possibly something of the kind is being provided in the new *I.M.E.*, Part III. (*b*), which has not yet been published. If not, should some officer with sufficient experience in the mathematics of this subject care to undertake the task, his work would, it is certain, be blessed by any R.E. officer who may in future be faced with the problem on service.

Yours truly,
"ONE OF THE AVERAGE R.E. OFFICERS."

The Editor, *R.E. Journal.*

THE "OTTER."

SIR,

With reference to Notes on Fieldworks published in the *R.E. Journal* of September, 1913:—

I have found that the construction of an "otter" as used by Lt.-Col. Tylden-Pattenson on the Cabul River is not generally known. Perhaps the following extracts from an Anglers' Library may be found instructive.

For those of your readers who are not anglers I would point out that the "otter" as described in these extracts is nowadays regarded as a poachers' instrument, and is illegal.

Yours faithfully,
R. N. HARVEY, *Lieut.-Colonel.*

Fortification School, S.M.E., Chatham,
28th January, 1914.

The Editor, *R.E. Journal.*

DESCRIPTION OF "OTTER."

(Extract from *The Erne, its Legends and its Fly Fishing.** By the Reverend Henry Newland. Pp. 53, 54, and 55).

An otter is a thin piece of board, about 4 ft. long and a foot or so broad, cut into the shape of a fore-and-aft midship section of a ship. This is leaded on the edge that represents the keel, so as to swim edge-ways. The principle on which it acts is that of a river barge, where the towing line is so adjusted, that the barge proceeds in a straight line through the water, though the line acts at an angle.

In the case of the otter, that part of the towing line nearest the float, which is technically called the back line, is made of three-fold barbers' silk, light, but very strong, to which, at intervals of 3 or 4 ft., are looped all manner of flies, to the number of from 15 to 30; to this is attached an ordinary salmon reel line, which generally leads through the rings of a short, stiff rod.

When all is ready, the float is launched by an attendant, the fisherman, with the rod in his hand, either taking a boat or following the line of

* Published by Chapman & Hall, 1851.

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the coast, and giving line or reeling up, as occasion requires. On account of the particular angle at which the line acts, the otter, on being pulled, slips out to sea, somewhat on the principle of a boy's kite, keeping nearly at right angles with the fisherman's course, and, consequently, exhibiting all the flies to any fish that may be lying between it and him.

The line being fastened to the upper edge of the float-board, a strong pull from either fish or fisherman would lay it flat on the water; and then the fisherman is always able to draw it towards him, though, as long as the draft is not too great to prevent it from swimming on its edge, its tendencies are slightly outward.

To balance and manage such a machine as this requires considerable ingenuity; but, for all that, it finds small favour with sportsmen, because it necessarily pricks and frightens ten times as many fish as it catches.

(Extract from *The Practice of Angling, particularly as regards Ireland.** By O'Gorman. Vol. II., pp. 56 and 57).

The machine called an otter consists of a deal board, about 4 ft. in length, and a foot or more in diameter, shaped somewhat like the keel of a boat. One side of the board is much thicker than the other, and bored with holes about an inch in diameter, for about 6 in. in depth, into which lead is poured, which renders it steady in the water. The upper edge of the board is much thinner: three or four small holes are made in the centre of the side of the board, through which whipcord is run, and it requires some dexterity to arrange these cords, as on them depends the success of its operation. To these cords is attached a strong cross line, with any number of flies that may be deemed requisite, and it certainly will make its way against even a strong wind, and with such effect, as to fatigue the rower of the boat opposite, from which it is always keeping away . . . rods are not necessary—a wheel and line, or a long cord, are sufficient, and one, or, at most, two persons, can manage it . . . the tackling must be course, as the board generally acts the part of the angler . .

* Published by William Curry, Junr., & Co., 1845.

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WORKSHOP NOTES.

By I.R.E.M.

THE following notes may be of interest to officers who have to maintain machinery or workshops, and who have not had opportunities of seeing up-to-date shops. They are the result of actual experience in an existing R.E. shop, and are possibly therefore of more practical interest than a mere description of an up-to-date commercial shop where costly machinery is installed for repetition work, and is not justifiable in a repair shop.

In many cases repairs have to be carried out to high-speed enclosed engines, and to other new machinery which requires more accurate work than some R.E. shops are capable of executing. It will often be found that spare parts of engines purchased from the makers are not usable, as journals which have worn oval must be turned or ground true, and holes bored or reamered to make them round, and that consequently the spare parts will not be a good fit. It is therefore desirable, particularly abroad, to be able to accurately make all the simpler working parts of machinery and thus save much delay and expense in maintenance.

Modern practice also tends towards increased use of electrical machinery for all purposes, and a knowledge of electrical work is consequently becoming essential to machinery officers. In this connection two useful testing circuits are described.

Lathes.—Modern lathes are similar in principle to the lathe usually found in R.E. shops, and the most important improvement consists in the self-acting feeds being positively driven by variable spur gears, independent of leading screw and usual change wheels, which enables the work to be more rapidly machined and more accurately finished.

Many old lathes can, however, turn out accurate work if the headstock bearings are renewed and all end play eliminated.

The most important innovation of recent years is the use of high-speed tool steel, in place of the high-percentage carbon steel issued by the A.O.D. The work is not only turned out with much greater rapidity and time saved in grinding and tempering tools, but modern high-speed steel will machine metals that the high carbon steel will not cut at all. By the use of a suitable tool holder adapted to take

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square or round section tools, no forging of tools is necessary, the tool being a piece of steel broken off the bar as purchased with just the cutting edge ground. The extra cost of the steel is more than compensated for by the extra work turned out. An electric grinding attachment fixed to the tool rest is often of great use in accurately grinding journals, bores of cylinders, etc. (see *Photo* I.), and can be purchased for about £15; this handy attachment when not in use on the lathe can be used as an ordinary tool grinder.

Milling Machines (see *Photos* II. and III.) are rapidly superseding shaping machines. The former can be purchased with a dividing head attachment and can then machine a great variety of work with great accuracy, and the following are a few of its most useful applications :—

Cutting spur gears from blanks.
Fluting taps and reamers.
Cutting keyways.
Cutting squares and hexagons on steel spindles.
Surfacing the butts of bearings.
Surfacing main bearings and general surfacing work.
Slitting metal.
Profiling.
Slotting.

The use of a milling machine necessitates provision of a cutter grinder both for regrinding worn cutters and grinding cutters true after being hardened.

A cutter grinder (see *Photo* IV.) can also be used for grinding case-hardened steel spindles true after quenching, and for grinding twist drills. The latter must be accurately ground in order to drill holes truly round, and at as great a speed as possible.

Sensitive Drill (see *Photo* V.).—Cheap, light sensitive feed drilling machines cost about £12. These machines have suitable tables for drilling work at any angle, and are much handier and quicker in operation than radial drills.

Furnace.—A muffle furnace heated by either gas or oil is essential for subjecting steel to the correct heat treatment. Messrs. Fletcher, Runnell & Co., of Warrington, specialize on these furnaces, which are largely used for case-hardening and carbonizing steel, hardening cutters, dies, taps and reamers. An electrical pyrometer is a useful accessory when used in conjunction with Brearley's "sentinels." The latter are fuzible salts which liquefy at a fixed temperature and immediately solidify again on the temperature falling below the melting point.

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The sentinels are inexpensive and, by using several with different melting points, the heat of the furnace can be estimated and the desired temperature can be maintained. Small errors in the temperature will spoil steel or cutters under heat treatment. The usual method of hardening mild steel with prussiate of potash is not good enough for engine work, because the hard skin is extremely thin and is removed when grinding the object true after quenching. A low carbon mild steel, containing from 0·15 to 0·2 per cent. carbon, can be carbonized and hardened in a muffle furnace to give any desired thickness of glass hard surface, and reheated and treated to maintain a strong and fibrous core. This process is invaluable for motor gears, gudgeon pins, and all spindles and pins subject to excessive wear.

The undermentioned materials, which are not usually kept in Service workshops are of great use in engine work :—

(*a*). Mild steel 0·15 to 0·2 per cent. carbon for case hardening; this can be forged to the shape required, annealed, machined, hardened and finally ground to size.

(*b*). Chrome vanadium steel contains about ·25 per cent. C., 1·25 per cent. Ch. and 0·15 per cent. vanadium; this steel can be forged, annealed and machined. This is of great use for shafts and rods which are heavily stressed, and for such parts as cross-head pins of high-speed engines, which require great strength.

(*c*). A 3 per cent. nickel steel. This steel can be forged, annealed and then machined to make new valves for internal combustion engines.

(*d*). Cast phosphor bronze used for bushes and small bearings. This is cheaper to buy and easier to machine than the solid bar. The following small stores are of great use :—

(1). Portable electric drills to drill holes in mild steel up to $\frac{9}{16}$ in. fitted with change speed gear, as in Messrs. Wolf's drills; these drills save an immense amount of time compared with ratchet drills.

(2). Carborundum wheels of various grades suitable to several classes of work. Special attention must be paid to the grinding speed and to the makers' instructions.

(3). Centre drills for preparing ends of spindles, etc., to fit the poppet centres of lathes.

(4). Standard taper reamers.

(5). Standard taper pins for use with the reamers.

(6). Adjustable parallel blocks for use on the surface plate.

(7). Standard keys.

(8). Starrett's scribing blocks.

(9). Internal and external micrometers to read to ·001 in.

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Electric Motors.—The use of electric motors for driving machine tools, drills, buffs, etc., is not only more convenient and economical than driving shafting from an engine, but it saves much time in starting and looking after the shop engine. Motors are particularly economical in the smith's shop for driving the fans for the forges and a power hammer, and under these conditions a smith's striker is rarely required and labour is economized.

Spring Hammers.—For small shops light spring hammers can be bought for about £28, capable of forging 2½-in. mild steel and with hammer head weighing some 56 lbs.

High-Pressure Testing Circuit (see *Fig.* 1).—The testing of insulation of electrical machines and instruments is quickly and efficiently done by applying a high-tension alternating current, at a pressure of 1,000 to 2,500 volts as desired, between the windings and frame of the machine. A circuit diagram is added showing a simple circuit designed to give a visible indication of whether the insulation will withstand the test, and to allow sufficient current to flow through a fault to indicate, by sparking or burning of the insulation, the position of the fault, without allowing any excessive current to pass. The high-tension circuit has a bank of carbon filament incandescent lamps in circuit, so that when the wandering leads make contact to complete the circuit, each lamp has its designed voltage applied. For instance a bank of ten 200-volt 50-watt lamps in series on a 2,000-volt circuit provides for a difference of potential of 200 volts at each lamp, and ensures that only the amount of current required to fully light each lamp can flow in the circuit, which in this case is 0·25 ampères.

The test of insulation is simple in the extreme, and consists in placing one lead on the winding of the machine under test, the other lead on the frame, and watching to see if the lamps glow. The current will jump a considerable air gap should the insulation break down. The insulation resistance of machines, as measured by instruments, varies very largely with the amount of moisture present, and is not always a reliable guide as to the efficiency of the machine in service—but a high-pressure test is of a much more searching nature.

If a supply of alternating current is not available, one can generally be obtained by adding two slip rings to the armature of any direct current generator or motor, and by connecting them to two coils 180 degrees apart electrically.

The combined cost of pressure-testing transformer, lamps and leads should not exceed £12. The instrument transformer and one voltmeter can be added, but are not essential.

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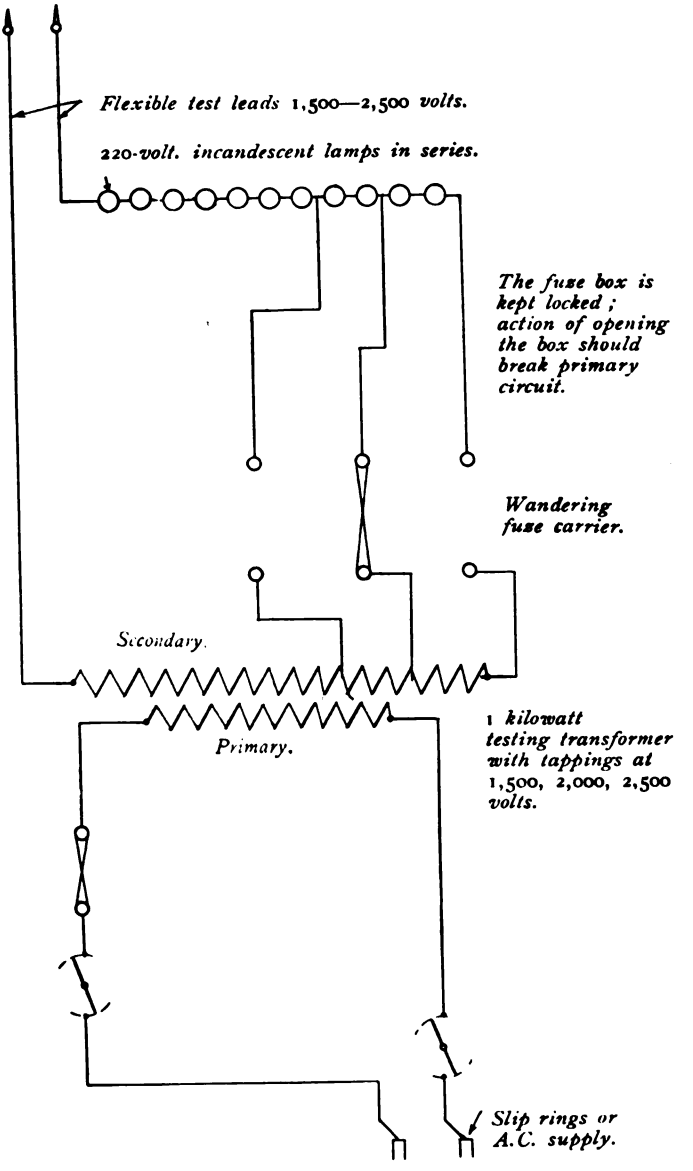
Flexible test leads 1,500—2,500 volts.
220-volt. incandescent lamps in series.
The fuse box is kept locked; action of opening the box should break primary circuit.
Wandering fuse carrier.
Secondary.
Primary.
1 kilowatt testing transformer with tappings at 1,500, 2,000, 2,500 volts.
Slip rings or A.C. supply.

FIG. 1.—*Circuit Diagram of High-Pressure Electric-Testing Set.*

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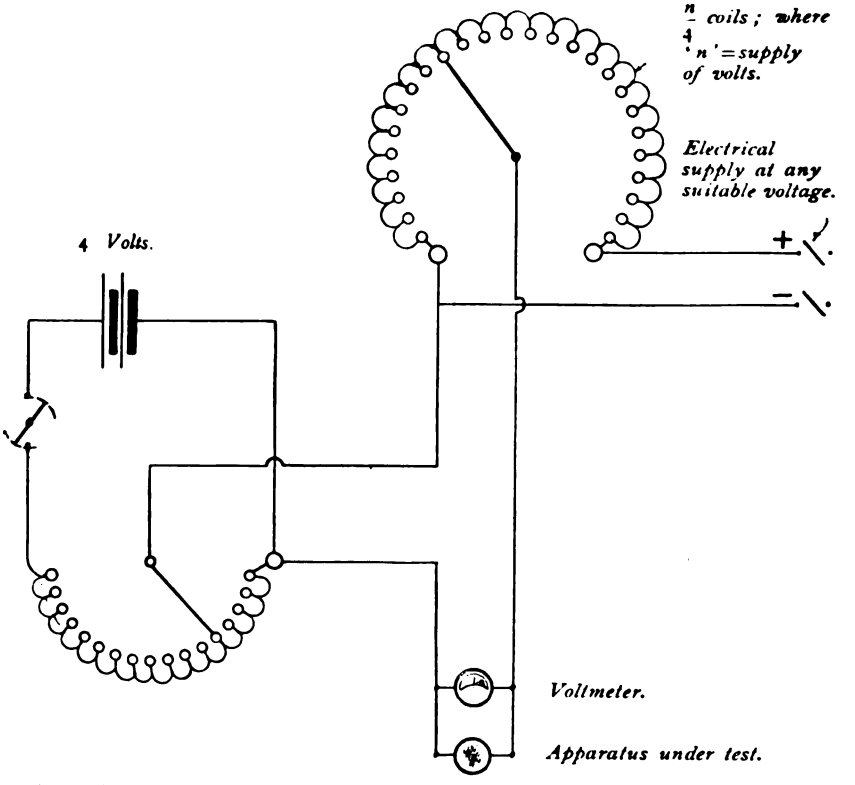
For Variable Voltage Circuit (see *Fig.* 2).—A circuit diagram of a circuit to give any voltage in steps of 0·1 volt at a time is added and is self-explanatory. This circuit is of great assistance in calibrating voltmeters, adjusting instruments and other tests.



A supply of any suitable voltage can be obtained by using suitable resistances with suitable number of contacts.

FIG. 2.—*Variable Pressure Electrical Calibrating Circuit.*

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POSSIBLE FUTURE DEVELOPMENTS IN AEROPLANE DESIGN.

By LIEUT. B. T. JAMES, R.E.

AEROPLANE design is now advancing with such swiftness that further progress, without some radical departure from present lines, seems impossible. Theory, however, suggests several methods by which improvements might be made, and it is with the object of investigating the possibilities of some of these improvements that the present article has been written.

The subject is an extremely interesting one from a scientific point of view, and for the benefit of those who may not have studied the subject I have endeavoured to explain all technical points as they occur. The science of aeronautics is founded as much upon experiment as upon pure science, and it will therefore be necessary to take certain things for granted. Where any assertion is made which is not supported by a definite proof, it may be assumed that it is sufficiently supported by experiment.

Briefly speaking the greatest limitation of a modern aeroplane is its limited speed range and the difficulty of landing a fast machine slowly. Machines can now be built to travel at speeds as high as 125 miles an hour, but their landing speed is so great that they cannot with safety be flown across any but the most ideal country, and as practical machines they are therefore useless. They require a field at least half a mile square and with a good surface, in order to land without damage.

The problem which designers have to face is the production of a machine with a greatly increased speed range, which can fly at high speeds, and whose speed can be reduced for landing to 45 miles an hour or thereabouts.

Theory tells us that there are two methods by which this result can be obtained, firstly by increasing or decreasing the wing surface while the machine is in the air, and secondly by increasing or decreasing the camber (*i.e.* the curve) of the wings. The "camber" is usually measured as a fraction of the "chord" or distance from front to rear of the wings. The reason for the first of these is fairly simple. The lift of a plane is expressed by the following equation :—

$$P = kSV^2$$

where P is the lift of the planes ;
S is the area of the planes ;
V is the velocity of the machine ;
k is a coefficient, which is determined by experiment for various angles of incidence of each particular wing shape.

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In the case of any given machine P is constant and equal to the weight of the machine.

We have therefore

$$V^2 = \frac{P}{kS},$$

so that V^2 varies inversely as the surface. It is not quite so easy to see how the alteration of camber alters the speed of the machine, as the proof of this is due more to experiment than to theory, but it is due to the fact that wings of small camber are found to give generally smaller values of k than wings of larger camber, and hence it is necessary to fly at higher speeds in order to obtain the necessary lift from them.

We see then that two methods of increasing the speed range are possible, one by increasing or decreasing the wing surface, and the other by increasing or decreasing the camber. Of these two methods, the first can be dismissed without much comment as being beset with too many practical difficulties to be possible at any rate for some time, but this is by no means the case with the second method. The difficulties here being by no means insuperable. For instance, it should be quite possible to construct a machine having three main wing spars, instead of the conventional two, and to increase or decrease the camber of the wing by altering the relative positions of these spars. The same movement could probably be used at the same time for lateral control of the machine, if suitable arrangements were made.

Many practical difficulties exist in the design of such a machine, chief among which would probably be the design of the ribs. However I do not wish to discuss constructional problems. My object is, taking reasonable assumptions for the weight of machine, horse-power, body resistance, etc., to try, if possible, to find out what are the possibilities, and what are the limitations of a machine with wings of variable camber.

With this object, taking fairly practical assumptions, I have carefully worked out the probable speed and power curves which could be obtained in practice with a variable camber machine. The data which I have used are as follows:—Gross weight of machine, 1,300 lbs.; B.H.P. of engine, 110; propeller efficiency, 75 per cent. at the maximum speed of the machine (165 foot-seconds) decreasing to about 65 per cent. at 80 foot-seconds.

Lift coefficients and lift drift ratios are taken from wings tested by the National Physical Laboratory.

The resistance of body, under carriage, struts, wires, etc., is taken as $\cdot 01\ v^2$ (v being the flying speed in feet per second); this gives a slightly better value than the Royal Aircraft Factory's graphs of BE_2 aeroplanes which are very well borne out in practice.

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Fig. 1 in the *Plate* shows graphs of the horse-power required to propel the machine at various speeds, with wings of various cambers. Curve 8 gives the effective B.H.P. of engine and propeller at various speeds.

The first thing that will be noticed is that the curves for wings with cambers greater than ·075 chord (shown dotted) all lie within the other three curves, and that none of them give as low a minimum speed as this wing. This is due to the fact that the efficiency of the wings falls off considerably when the camber is increased beyond this point, the ratio of lift to drift or head resistance not being nearly so large for these wings as for the wings of lesser camber.

From this we see that no useful object will be gained by increasing the camber beyond ·075 chord. It will be shown later that very little could also be gained by decreasing the camber beyond ·025 chord. The designer will therefore be able to obtain his maximum speed range by varying the camber between the limits of ·025 chord and ·075 chord. This is not a large amount, and the fact that this small movement is all that is necessary is a great point in the designer's favour.

The curves for the various wings are all very similar in shape; the maximum speed attainable is 112·5 miles per hour, with a camber of ·025 chord, and the slowest landing speed is about 44 miles per hour, with a camber of ·075 chord. I also plotted the H.P. curves for a flat plate, which should be the limiting case, but its shape was so irregular that I have omitted it, as nothing seemed to be gained by its inclusion.

The next point to be considered is the alteration of the characteristics of the machine when the camber is varied, and with the object of investigating this I have plotted in *Fig.* 2 these various characteristics as a function of the camber. These curves are all of a simple nature, and speak for themselves.

With regard to the maximum speed, this might possibly be increased by using a camber slightly less than ·025 chord, but probably only to a very small extent, as the power available for climbing and for emergencies (*vide* Curve No. 3) appears to decrease rapidly as the camber is diminished. The minimum speed (63 ft. per second) is obtained with a camber of about ·07 chord; the best climb (1,220 ft. per minute) is obtained with a camber of ·075 chord; and the best glide (1 in 7·65) with a camber of ·055 chord (approximately).

Briefly summing up, the following advantages would seem to be obtainable from a machine with wings of variable camber, viz.:— A very high maximum flying speed combined with a very low proportionate landing speed, and also a better climbing rate and a better gliding angle than could probably be obtained with wings of fixed camber; because—and here lies the root of the matter—the pilot of a variable camber machine can always adjust his wings to the

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best possible camber for whatever he wants to do; if he wants to glide, he sets his wings to the best possible camber for gliding; if he wants to climb, he adjusts them to the best camber for climbing; and if he wants to fly fast, he opens his throttle and reduces his camber, and away he goes.

I should like to point out also that I have, if anything, rather underestimated the possibilities of the variable camber machine, which, in the light of what has recently been done by British designers with the fixed camber type of machine, should give even better results than I have indicated.

It might now be supposed that, having produced by means of variable camber a machine with a high-speed range, nothing further was necessary to enable the pilot of a high-speed machine to land in a small field. As will be shown later, however, this is by no means the case, and in order to completely solve the problem it is necessary to approach it from a different point of view. Having now dealt with the possibilities of variable camber, I wish to suggest another method which, used in conjunction with variable camber or by itself, should make the problem of landing a fast machine in a small field still easier.

At the present time, by far the greatest difficulty which a pilot has to contend with is the landing of a fast modern machine in a small field. The difficulties are enormously increased if the field is surrounded by high trees or other obstacles. The landing of a modern machine without damage when flying across country, when for some reason or other the engine has failed, requires the greatest skill and judgment on the part of the pilot. The solution of this problem is of special importance in England, where large areas of country exist which are composed almost entirely of small fields with high trees round them, in which the landing of a fast machine is a difficult and often dangerous proceeding. The country chosen for the manœuvre area last year provides some very typical examples of this type of country.

In attempting to solve this question, I will first try to show what happens when a pilot attempts to land in a small field. *Fig.* 3 represents a section of a small field surrounded by high trees. The only way in which it is possible to land a fast machine in such a field is by finishing the Volplané at as "flat" an angle as possible, so as to reduce the flying speed, and then to come in just over the tops of the trees (see AB, *Fig.* 3). This requires the most accurate judgment on the part of the pilot, and is not a safe manœuvre at any time, as there is always the risk of a wind gust dropping the machine into the trees at the near side of the field at the last moment. Moreover, a machine gliding at its slowest gliding speed is seldom properly under control.

If the machine comes into the field at a slightly steeper angle

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(*vide* the dotted lines, *Fig.* 3), owing to the high efficiency of the machine (resistance of body, struts, wires, etc., being cut down to a minimum) the speed of the machine increases enormously, and the pilot finds, when he flattens out to land, that his machine is travelling at a speed far in excess of the speed at which he can safely do so. He must therefore glide on until his speed has dropped sufficiently to allow him to land. By this time he probably finds himself colliding with the hedge on the far side of the field.

The above difficulties, which are due chiefly to the small body resistance and high efficiency of the machine, occur to almost as large an extent with wings of large camber as with wings of small camber, so that it is evident that variable camber does not really solve the problem. It might be possible to land a variable camber machine slowly, but it would still be extremely difficult to land it in a small space.

The difficulties are almost entirely due to the high state of efficiency of the modern machine ; when glided at any angle which is appreciably steeper than its normal gliding angle, it increases its speed at an alarming rate, and on flattening out, owing to its high efficiency, its momentum carries it an enormous distance before its speed falls off sufficiently to allow the pilot to land it. The faster and more efficient the machine, the harder it is to land it in a small field without damage.

The obvious remedy to these difficulties is to provide a brake of some sort. The various forms of brake which can be used can be classified broadly under two headings.

Firstly " land " brakes, consisting of some form of skid, which catches in the ground, or a brake applied to the under-carriage wheels. This form of brake relies entirely for its effect on friction with the ground.

Secondly " air " brakes, consisting of some arrangement of flaps or other suitable attachment whereby the air resistance of the machine is increased. An " air " brake should be so designed that it can be applied without danger when the machine is in the air, and at any height.

Of these two, the land brake has already been tried on several machines. This form of brake is of very little use and does not really solve the problem, as it cannot come properly into operation until a large proportion of the weight of the machine is resting on the ground. This does not happen till after the machine has landed and run some distance. Until the machine has already slowed up considerably after landing, a large proportion of the weight is taken by the wings, and is not therefore available for " braking " purposes. The fault of the " land " brake is that it does not come into operation till after the machine has landed, and it is while the machine is still in the air that the real difficulties occur. The " land " brake is therefore not of much use.

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The " air " brake on the other hand does exactly what is required, for it increases the air resistance of the machine while it is still in the air, and thus makes the machine inefficient. It is obvious that this is exactly what is wanted. The air brake enables the pilot to bring his machine into the field at a much steeper angle and at a greater variation of angles without his speed becoming excessive, and when he flattens out, it checks the speed of the machine and enables him to land almost at once.

To obtain the best effect from the air brake it would often be necessary to apply it while the machine was in the air and at a considerable height. It has been suggested that an air brake used in this manner would upset the stability of the machine, and would for this reason be dangerous. Careful design and careful experiment are essential to secure safety. It might even be found necessary to use larger rudders and tail planes for this purpose. Given careful design however there seems to be no reason why it should not be safe to apply the air brake at any height.

With the object of finding out how far the gliding angles and speeds of a machine would probably be affected by an air brake, I have again taken an imaginary machine. The results are shown in *Fig.* 4, in which are plotted curves showing the gliding angles of the machine with the air brake applied, and without it. The assumptions are the same as before, the wing with a camber of ·05 chord being used for these calculations. An air brake has been assumed which when applied doubles the " body " resistance of the machine.

Approximate calculations, based on Eiffel's experiments, show that two flat plates each about 2 ft. 0 in. square, extended at right angles to the direction of motion of the machine, would be sufficient to have this braking effect. An air brake of this power would therefore be a practical proposition. From *Fig.* 4 it can be seen that the best gliding angle of 1 in 7·7 is reduced to approximately 1 in 5·6 by the application of the air brake. The speed that would be attained by a fairly steep Volplané of 1 in 4·5 is reduced from 95 miles per hour to about 65 miles per hour, while it would be possible to descend at an angle as great as 1 in 3 with the air brake on without exceeding 85 miles per hour.

I have attempted to show these results graphically in *Fig.* 3. Although up to the present no machine has yet appeared with wings of variable camber it is interesting to note that experiments are already being carried out with air brakes, and it will therefore not be long probably before at any rate one of the developments which I have endeavoured to discuss becomes an accomplished fact.

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FIG 3.

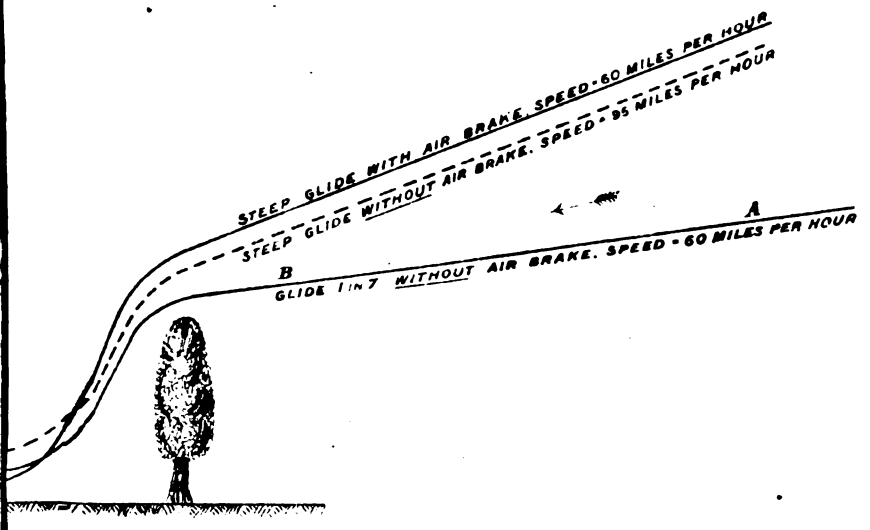
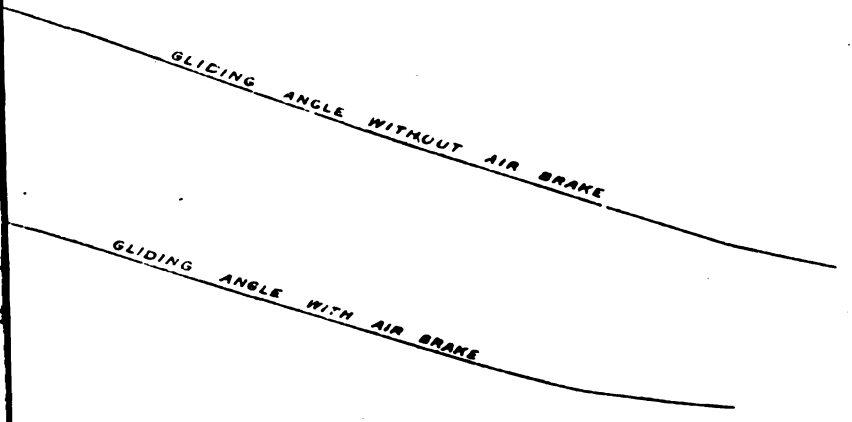

STEEP GLIDE WITH AIR BRAKE. SPEED - 60 MILES PER HOUR
STEEP GLIDE WITHOUT AIR BRAKE. SPEED - 95 MILES PER HOUR
A
B
GLIDE 1 IN 7 WITHOUT AIR BRAKE. SPEED - 60 MILES PER HOUR

FIG. 4.



DING SPEED (FT PER SEC)

80 100 110 120 130

60 70 80 90

ING SPEED (MILES PER HOUR)

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SIEGES AND THE DEFENCE OF FORTIFIED PLACES BY THE BRITISH AND INDIAN ARMIES IN THE XIXth CENTURY.

By COLONEL SIR EDWARD T. THACKERAY, V.C., K.C.B. (LATE R.E.).

THE following accounts of Sieges of the British and Indian Armies in the 19th century have been arranged and compiled in a comparatively abbreviated form. They commence with the Capture of the Fortress of Asseerghur in November, 1803, and will be continued in consecutive numbers of the *R.E. Journal*. Many histories and books on military subjects have been referred to, and the sources of information from which the accounts of the sieges are derived will, as far as is possible, be mentioned.

It is not proposed, or intended, that the descriptions of the various sieges should be given in very minute detail, and it would be impossible within the scope of a work of this kind to relate more than the salient points of the sieges. But it is hoped that the accounts —even in their abbreviated form—may be of interest to officers of the Corps, to officers of other branches of the Service, and to subscribers to the *R.E. Journal*.

In the present number the following sieges are dealt with :—

(1). The Capture of Asseerghur, November, 1803.
(2). Siege of Gawilghur, December, 1803.
(3). Siege of Asseerghur, March, 1819.
(4). Blockade of Cadiz, February, 1810.

In compiling the accounts of the above sieges the following works have been consulted :—*History of the Madras Engineers*, by Colonel H. M. Vibart, R.E. (by kind permission) ; *Wellington's Despatches ;* Napier's *History of the Peninsular Wars*.

E.T.T.

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(1).

CAPTURE OF ASSEERGHUR (*October*, 1803).

The first siege of Asseerghur took place during the first Mahratta War in 1803.

The British force under Wellesley having totally defeated at the Battle of Assye the enemy under Scindia and the Bhonsla in September, Colonel Stevenson, as reported in the following despatch,

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advanced upon the Fortress of Asseerghur and captured it after a short siege.

The fort is situated 2 miles from the end of the great western ranges of the Satpoora Hills, and 16 miles north of Boorhanpore. It is placed in one of the principal passes from the Deccan into Hindustan, and the natural defence that it receives from a precipice of rock on almost every side has been increased by a thick and lofty rampart of masonry—which is built on the summit of the rock—and by large cavities with guns, which at the time of the capture of the fortress by Colonel Stevenson in the month of October, 1803, commanded the country in every direction.

The general height of the position above the plain is 750 ft., and the total circumference including the upper and lower forts is 4,600 yards, or considerably over 2½ miles.

The third enclosure, which contains the lower fort, is called Malighur.

The following despatch from Major-General Wellesley to the Governor-General of India gives a detailed account of the capture of this fort :—

CAMP, *6th November*, 1803.

To the GOVERNOR-GENERAL.

" I now proceed to give your Excellency a detailed account of Colonel Stevenson's operations against Asseerghur.

On the 16th October he advanced to Asseerghur, and encamped 3 miles south of the fort. The remains of the enemy's infantry had fled towards the Nerbudda on the previous day, in the state which I reported them to be, in my letter of the 24th October ; and Colonel Stevenson determined to attack Asseerghur.

On the 18th he reconnoitred the fort, attended by a squadron of cavalry and the piquets of the Native infantry ; and having seen a favourable opportunity, attacked the pettah and carried it, and made a lodgment within 150 yards of the lower wall of the fort. In the evening he reinforced the troops by a battalion. On the 19th all the preparations were made for carrying on the siege ; and two batteries were ready to open at 2 o'clock in the afternoon of the 20th ; one to breach the upper wall, and another of four brass 12-pounders, to destroy the defences of the lower wall.

On the 18th Colonel Stevenson had sent a flag of truce to the killadar to summon him to surrender the fort, to which message he did not receive a decided answer. The communication was continued, but Colonel Stevenson did not relax his operations against the fort, as there was reason to believe that the negotiation was carried on only to give time to Dowlat Rao Scindiah to come to his relief. Before opening the batteries, Colonel Stevenson apprised the killadar of the terms on which he should surrender the fort ; which were that the garrison should march out with their private

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property, and be allowed to go where they might think proper, and that their arrears should be paid to the amount of 20,000 rupees.

After the batteries had opened about an hour, a white flag was shown from the walls of the fort, which was the signal that had been agreed upon in case the terms should be accepted; hostages were sent down, and an engagement made that the fort should be delivered up on the following morning. It was accordingly evacuated; the garrison carried off their property in security, and received the sum agreed to be paid to them.

Colonel Stevenson mentions in high terms the conduct of the officers and troops under his command; and I cannot omit to take the opportunity of expressing to your Excellency my sense of the merits of Colonel Stevenson and of the body of troops under his command. Upon every occasion I received from the Colonel the most cordial and zealous assistance; and the troops under his command are in the highest state of discipline and order, and fit for any service in which they can be employed.

On the 16th, 9 officers, 4 sergeants, and 1 matross, formerly in the service of Dowlat Rao Scindiah, delivered themselves up to Colonel Stevenson under your Excellency's proclamation of the 29th August.

I have the honour to enclose a return of the killed and wounded of the troops under the command of Colonel Stevenson, during the operations against Asseerghur. Hereafter I shall have the honour of transmitting return of the ordnance, stores, grain, and other property captured in that fort."

(2).

SIEGE OF GAWILGHUR (*December*, 1803).

The second siege dealt with is that of Gawilghur which took place during the same campaign. It was undertaken by Major-General Wellesley himself, and a full and detailed account of his operations is given in the following despatch to the Governor-General in India:—

CAMP AT DEOGAUM, 15*th December*, 1803.

To the GOVERNOR-GENERAL.

"After the Battle of Argaum I determined to lose no time in commencing the Siege of Gawilghur. I accordingly marched on and arrived at Ellichpoor on the 5th instant, and halted there the 6th; in order to establish a hospital there for the wounded in the Battle of Argaum.

The fort of Gawilghur is situated in a range of mountains between the sources of the rivers Pooma and Taptee. It stands on a lofty mountain in this range, and consists of one complete inner fort which fronts to the south, where the rock is most steep; and an outer fort, which covers the inner to the north-west and north. This

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outer fort has a third wall, which covers the approach to it from the north by the village of Labada. All these walls are strongly built, and fortified by ramparts and towers.

The communications with the fort are through three gates; one to the south with the inner fort; one to the north-west with the outer fort and one to the north with the third wall. The ascent to the first is very long and steep, and is practicable only for men; that to the second is by a road used for the common communications of the garrison with the countries to the southward; but the road passes round the west side of the fort, and is exposed for a great distance to its fire; it is so narrow as to make it impracticable to approach regularly by it, and the rock is scarped on each side. This road also leads no further than to the gate. The communication from the northern gate is direct from the village of Labada, and here the ground is level with that of the fort; but the road to Labada leads through the mountains for about 30 miles from Ellichpoor; and it was obvious that the difficulty and labour of moving ammunition and stores to Labada would be very great.

However, after making inquiry at Ellichpoor it appeared both to Colonel Stevenson and me, that this point of attack was, upon the whole, the most advantageous, and we accordingly adopted it.

Colonel Stevenson had equipped his corps at Asseerghur for the Siege of Gawilghur, for which service it had long been destined; and I therefore determined that he should make the principal attack by Labada, while I should cover his operations with my own division and all the cavalry; and if possible assist them by other attacks to the southward and westward. On the 6th inst. the 1st Batt. 2nd Regiment, under Lieut.-Colonel Chalmers, and two companies of the 94th, and the 1st Batt. of the 6th, under Capt. Maitland, were detached; the former to drive the enemy from the ground which they occupied to the southward of the fort; and the latter to seize the fortified village of Damergaum, which covers the entrance of the mountains by the road by which Colonel Stevenson was to pass towards Labada, and to protect the parties sent forward to reconnoitre and repair the roads in the mountains. Both these detachments succeeded.

On the 7th both divisions marched from Ellichpoor; Colonel Stevenson into the mountains by Damergaum, and my division towards the southern face of the fort of Gawilghur. From that day till the 12th, on which Colonel Stevenson broke ground near Labada, the troops in his division went through a series of laborious services, such as I never before witnessed, with the utmost cheerfulness and perseverance. The heavy ordnance and stores were dragged by hand over mountains, and through ravines, for nearly the whole distance, by roads which it had been previously necessary for the troops to make for themselves.

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On the 12th at night, Colonel Stevenson erected two batteries in front of the north face of the fort; one consisting of two iron 18-pounders, and three iron 12-pounders, to break the outer fort and third wall; and one consisting of two brass 12-pounders, and two 5-in. howitzers, to clear and destroy the defences on the point of attack.

On the same night the troops of my division constructed a battery for two iron and two brass 12-pounders on the mountain under the southern gate, with a view if possible to breach the wall near that gate; or at all events to draw the enemy's attention to that quarter. Unfortunately the iron guns could not be moved into the battery, notwithstanding the utmost exertions of the troops; and the fire of the brass guns produced but little effect.

The fire of all these batteries opened on the 13th in the morning; and on the 14th, at night, the breaches in the outer walls were practicable. All the arrangements were then made for storming on this day. Lieut.-Colonel Kenny, of the 11th Regiment, commanded the party for the storm, consisting of the flank companies of the 94th Regiment, and of the Native Corps in Colonel Stevenson's Division, supported by the 94th Regiment, and Lieut.-Colonel Haliburton's Brigade, with Lieut.-Colonel Maclean's Brigade in reserve. At the same time I made two attacks from the southward to draw the enemy's attention from that quarter; one, under Lieut.-Colonel Wallace, consisting of the 74th Regiment, 5 companies of the 78th and 1st Batt. 8th Regiment, on the southern gate; and one under Lieut.-Colonel Chalmers, consisting of 5 companies of the 78th and the 1st Batt. 10th Regiment, on the north-west gate. These last attacks could be of no service, except to draw the enemy's attention from that from the north; unless they should succeed in blowing open the gates; and till they should communicate with detachments from Colonel Stevenson's Corps, as they had no other means of entering the fort. All the troops advanced at about ten in the morning. The detachment under Lieut.-Colonel Chalmers arrived at the north-west gate at the moment when the enemy were endeavouring to escape through it, from the detachment of Colonel Stevenson's Corps, which had been sent to communicate with Colonel Chalmers; and he entered without difficulty.

The wall of the inner fort, in which no breach had been made, was then to be carried. After some attempts upon the gate of communication between the inner and the outer fort, a place was found at which it was possible to escalade the wall. Capt. Campbell, with the light infantry of the 9th Regiment, fixed the ladders against this place, escaladed the wall, opened the gate for the storming party, and the fort was shortly in our possession. The enemy's garrison was numerous. It consisted of Rajpoots, and a great part of Beny Singh's Regular Infantry, which had escaped from the

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Battle of Argaum, commanded by Beny Singh, himself. They were all well armed with the Company's new muskets and bayonets. Vast numbers of them were killed, particularly at the different gates. This service has, I hope, been performed, with small loss on our side. No officer has been killed; and but few wounded, that I have heard of, excepting Lieut.-Colonel Kenny, of the 11th Regiment, and Lieut. Young, of the 2nd of the 11th. In the performance of this service all the good qualities of British troops have been conspicuous to a degree which I have seldom witnessed. In bringing on their ordnance and stores to the point of attack, the troops of Colonel Stevenson's Division performed the most laborious work with a zeal for the service, and patience and perseverance never surpassed; and when opposed to the enemy, their conduct showed the same gallant spirit that has carried the British troops through so many difficulties in the course of the war.

Although the most laborious and the most brilliant part of the service did not fall to the lot of the troops of my division, I have to apprise your Excellency that they performed the part allotted to them in a manner perfectly satisfactory to me; and Lieut.-Colonel Wallace, Lieut.-Colonel Chalmers, and Capt. Beauman, commanding the Artillery, have received my thanks for the manner in which the two former led their divisions to the attack, and the latter exerted himself, to forward the service of the department.

I shall hereafter have the honour of transmitting to your Excellency a list of the killed and wounded, and returns of the ordnance and property captured in the fort."

(3).

SIEGE OF ASSEERGHUR (*March*, 1819).

In 1819 it was again found necessary to capture Asseerghur, and a force for this purpose was assembled under Brigadier-General Doveton and consisted of:—

Three regiments of Native cavalry.

Three and a-half battalions of European infantry.

Seven battalions of Native infantry.

Also a division brought down from Malwa by Malcolm composed of 1 regiment of cavalry, 4 battalions of Native infantry, with horse artillery and trains of both forces. Besides this, a further train was on its way detached from Sangor under Brigadier-General Watson. There were altogether 28 guns, 15 mortars and 19 howitzers.

The pettah is situated to the west of the fort in a hollow intersected by numerous ravines, and is commanded by the lower fort. The pettah was carried by assault at daybreak on March 18th, 1819, by the columns under Brigadiers Sir John Malcolm and Doveton.

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Doveton's Column, commanded by Colonel Fraser and led by H.M.'s Royal Scots, entered the pettah by the south-west gate at head of the Buttakerah Nullah; Malcolm's Column entered by the high road from Boorgaum, through a gap in the hills which covers the pettah on the north-east. The enemy were taken by surprise, made little opposition, and our troops soon established themselves under cover of the houses, with a trifling loss occasioned by fire from the lower fort.

The Engineer Department was established in a large bombproof pagoda in the centre of the pettah, and the troops occupied the street in advance, which runs parallel to the fort. On March 23rd the Engineers reconnoitred the east front of the fort to fire on ground for General Doveton's Encampment.

On March 27th the Ram Bagh under the north-east angle of the upper fort was occupied, and the Engineer Depôt stationed there.

On April 7th, the breaching batteries opened on the retaining walls, and with the assistance of a third breaching battery a practicable breach was nearly effected.

On April 8th the breaching batteries opened at daybreak. About 11 a.m. orders were received to cease fire, the killadar, Jeswant Rao Lar, having agreed to an unconditional surrender.

(4).

BLOCKADE OF CADIZ (*February*, 1810).

The fourth siege of the present series is that of Cadiz. In this instance the French were the besiegers whilst the British formed part of the defending force.

Before giving the details of this siege, it may be well to recall briefly the events which led up to it. It was in October, 1807, that Napoleon laid his first steps for the future conquest of Spain, by signing a secret convention with the Spanish minister for the partition of Portugal between France and Spain. For this purpose 28,000 French troops were to be sent into Spain for the ultimate occupation of Portugal, whilst an additional 40,000 were to be cantoned at Bayonne as a support to the first Corps. The natural result followed. Portugal was easily overrun by the Allies whilst the French reinforcements entered Spain and secured several of the Northern fortresses. Meanwhile the dissensions of the Spanish Royal Family provided Napoleon with a pretext for dethroning the Spanish Bourbons and for replacing them by his brother Joseph. This act was, however, immediately followed by a general uprising of the Spanish people, during which the people of Cadiz compelled the French warships there to surrender, and the levies of Andalusia forced General Dupont and 23,000 men to lay down their arms at Baylen. Sir Arthur Wellesley, also, landed with a British force and,

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after the Battle of Vimiera, Junot—who was in command of the French—agreed to evacuate the country. Napoleon now seriously turned his attention to the subjugation of Spain. In January, 1809, the British force under Sir John Moore was compelled to retreat and re-embark at Corunna and, although in the following July, Sir A. Wellesley again defeated the French at Talavera, by the end of the year they were virtually masters of Spain. In January, 1810, they entered Seville, overran Andalusia and pushed on to capture Cadiz. The city was at the time utterly unprepared for attack and there were under 1,000 men in the Isle of Leon. Fortunately General Alburquerque, on his own initiative and contrary to the orders he had received, realized the vital importance of saving the town. Pushing on with the greatest rapidity and by forced marches, he outmanœuvred and outstripped the French, and on the 2nd of February, after a march of over 260 miles he entered the Isle of Leon with 8,000 men.

Defeated in his attempt to surprise Cadiz, Victor spread his troops round the margin of the bay and commenced works of contravallation, 25 miles in length. Although the towns, the islands, the castles, the harbours, and rivers thus enclosed are too numerous, and in their relative bearings too intricate for minute description, the leading features shall in due course be given.

The blockade comprised three grand divisions, separately entrenched, namely, Chiclana, Puerto Real, and Santa Maria. The first resting its left on the seacoast was carried across the Almanza and Chiclana Rivers to the Zuraque, being traced for 8 miles along a range of thickly wooded hills bordering a marsh from 1 to 3 miles broad: both the line and marsh were traversed by those rivers, and by many navigable water courses and creeks, all falling into the Santi Petri, a natural channel connecting the upper harbour of Cadiz with the open sea. This channel, 9 miles long, 200 or 300 yards wide, and of depth to float a seventy-four, was the first Spanish line of defence. In the centre, the bridge of Zanzo, by which the only road to Cadiz passes, was broken and was also defended by batteries on both sides. On the right hand the Caraccas, or Royal Arsenal, situated on an island in the harbour mouth of the channel, and on account of the marsh not open to attack save by water or by bombardment, was covered with strong batteries and served as an advanced post. On the left hand the Castle of Santi Petri, also built upon an island, defended the sea-mouth of the channel.

Beyond the Santi Petri was the Isla de Leon, a vast triangular salt marsh, but having one high strong ridge in the centre, about 4 miles long, on which the town of Isla stands; this ridge within cannon shot of the Santi Petri offered the second line of defence.

At the apex of the Isla stood the Torre Gardo, from whence a low narrow isthmus 5 miles long connected it with the rocks on which

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Cadiz is built. Across the centre of the isthmus, a cut, called the Cortadura and defended by the large unfinished fort of Fernando, offered a third line of defence. The fourth and final line was the land front of Cadiz, regularly fortified.

On the Chiclana line, the hostile forces were only separated by the marsh. The Spaniards possessed the Santi Petri, but the French, having their chief depôts in the town of Chiclana, could always command the marsh, and might force the passage of the channel. For the Chiclana, Turaque and Almanza Creeks were navigable beyond the lines of contravallation, the thick woods behind furnished means of constructing an armed flotilla, and the Santi Petri itself, on both sides, could only be approached by water off the high road; or at best by narrow footpaths leading between the salt pans of the marsh.

The French centre, called the Puerto Real Division, extended from the Turaque on the right for a distance of 7 miles. This line ending at the town of Puerto Real was traced along a ridge skirting the marsh, so as to form with the position of Chiclana a half-circle. Puerto Real was entrenched; but a tongue of land 4 miles long projected from it perpendicularly towards the isthmus of Cadiz, being cloven in its whole length by the creek or canal of Trocadero. It separated the inner from the outer harbour, and at its extreme points stood the village of Trocadero, and the fort of Matagorda; opposed to which there was, on the isthmus of Cadiz, a powerful battery called the Puntales.

From Matagorda to Cadiz was above 4,000 yards; but from Puntales it was only 1,200, and was therefore the nearest point to Cadiz, and to the isthmus, and the most important post of defence. From thence the French could search the upper harbour with their fire, or throw shells into the Caraccas and the fort of Fernando; while their flotilla, safely moored in the Trocadero Creek, could quickly reach the isthmus and turn the Isla, with all the works between it and the city; nevertheless the Spaniards dismantled and abandoned Matagorda.

The Third or Santa Maria Division of blockade followed the sweep of the bay. Reckoning from the San Pedro on the left, to the Castle of Santa Catalina, the extreme point of the outer harbour on the right, was about 5 miles. The town of Santa Maria, built at the mouth of the Guadalete in the centre of this line, was entrenched, and the ground about Santa Catalina was extremely rugged.

Beyond these lines, which were connected by a covered way concealed by thick woods and finally armed with 300 guns, the towns of Rota and San Lucar de Barameda were occupied; the first, situated on a cape of land opposite to Cadiz, was the northern point of the great bay or roadstead; the second commanded the mouth of the Guadalquiver. Behind these lines of blockade, Latour

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Maubourg occupied Medina Sidonia with a covering division, his left being upon the upper Guadalete, his advanced posts watching the passes of the Sierra di Ronda.

General William Stewart reached Cadiz with 2,000 men the 11th February; 1,000 more joined him from Gibraltar, and all were received with enthusiasm. The Portuguese troops were equally well received, and soon 4,000 Anglo-Portuguese, and 14,000 Spanish regulars were behind the Santi Petri.

The ships recovered at Ferrol had been transferred to Cadiz, and thus were in the bay 23 men-of-war, four of the line and three frigates being British. The *Euthalion* and *Undaunted* also arrived from Mexico, with six millions of dollars, and thus money, troops, and a fleet were suddenly collected at Cadiz. Yet to little purpose. Procrastination, jealousy, ostentation, and a thousand absurdities marred every useful measure, and there was so little enthusiasm among the people that no citizen was enrolled, or armed, or volunteered either to labour or to fight.

Stewart's first measure was to recover Matagorda. In the night of the 22nd a detachment consisting of 50 seamen and Marines, 25 artillerymen and 67 of the 94th Regiment, pushed across the channel during a storm, took possession of the dismantled fort and effected a solid lodgment: the French cannonaded the work with field artillery all the next day, yet the garrison supported by the fire of Puntales, was immovable, and the remainder of February passed without any event of importance. Early in March the city wanted provisions, especially fresh meat, and a tempest beating on the coast from the 7th to the 10th of March, drove three Spanish and one Portuguese sail of the line, a frigate and from 30 to 40 merchantmen on shore between San Lucar and St. Mary's. One ship of the line was taken, the others were burnt and part of the crews brought off by boats from the fleet; but many men, amongst others a part of the 4th English Regiment, fell into the hands of the enemy, together with an immense booty.

On the 15th the enemy's outposts at Santi Petri were driven in by Major Sullivan, of the 79th, to cover an attack meditated against the Trocadero, but the design was baffled by the surf in one quarter and the difficulty of crossing a shoal in another. In the same month Mr. H. Wellesley, Minister Plenipotentiary, arrived; and on the 24th General Graham, coming from England, assumed the chief command of the British troops and immediately caused an exact military survey of the Isle to be made. It then appeared that the force hitherto assigned for its defence was quite inadequate. Twenty thousand soldiers, with redoubts and batteries, requiring the labour of 4,000 men for three months, were absolutely necessary; the Spaniards had only worked beyond the Santi Petri, and there without judgment. Their batteries in the marsh were ill-placed, their

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entrenchments at the sea-mouth were contemptible; the caraccas though armed with 150 guns was full of dry timber and could be easily burnt by carcasses. The interior defences of the Isla were quite neglected. Matagorda and the Trocadero had been abandoned, but the batteries beyond the Santi Petri had been pushed to the junction of the Chiclana road with the Royal causeway; that is to say 1½ miles beyond the bridge of Zanzo, and consequently exposed without support to flank attacks both by water and land.

It was in vain that the English engineers presented plans and offered to construct the works, the Spaniards would never consent to pull down a house or destroy a garden; their procrastination paralyzed their Allies, and would have lost the place had the French been prepared to press it vigorously.

Additional reinforcements reached Cadiz the 31st, and both sides continued to labour at their lines; but the Allies worked slowly and without harmony, the people's supplies were interrupted, scarcity prevailed, many persons were forced to quit the city and 2,000 Spanish troops were detached by sea to Ayamonte to collect provisions on the Guadina.

Matagorda was small, of a square form, without a ditch, without sufficient bombproofs, and having one angle projecting towards the land; it could only bring seven guns to bear, yet though frequently cannonaded it had been held 55 days, and now impeded the completion of the French works. A Spanish seventy-four supported with an armed flotilla moored on the flanks, and co-operated in the defence; but at daybreak on the 21st heavy batteries, hitherto masked by some houses on the Trocadero, sent a hissing shower of hot shot upon the ships and drove them for shelter to Cadiz. Then the fire of 48 guns and mortars of the largest size were concentrated on the little fort, and the feeble parapet disappeared in a moment before the crushing flight of metal. The naked rampart and the undaunted hearts of the garrison remained; yet the men fell fast, and the enemy shot so quick and close, that a staff bearing the Spanish flag was broken six times in an hour. The colours were then fastened on the angle of the work itself, to the discontent of both soldiers and sailors who besought their officers to hoist the British ensign, attributing their slaughter to their fighting under a foreign flag. Thirty hours this tempest lasted, and 64 men out of 140 had fallen, when General Graham, finding a diversion he had projected impracticable, sent boats to carry off the survivors. A bastion was then blown up under the superintendence of Major Lefebure, an engineer of great promise, but he also fell, the last man whose blood wetted the ruins thus abandoned.

Matagorda Point was soon covered with batteries by the French, but the war languished in front of Cadiz.

In May some French prisoners cut the cables of two hulks at Cadiz and drifted in a heavy gale to the French side; they beat off

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two of the craft sent after them by throwing cold shot from the decks, and about 1,500 saved themselves, despite of the fire from the allied fleet, and from the batteries. Cadiz was now a scene of great disorder. The English General was hampered by the perverse spirit of the authorities, and the Spanish troops were daily getting more inefficient from neglect.

Blake was then called to command in the Isla, and his presence produced some amelioration in the condition and discipline of the troops; and at his instance the British Engineers commenced a regular system of redoubts for the defence of the Isla. English reinforcements continued to arrive, and 4,000 Spaniards joined the garrison now within the lines; but such was the state of the Spanish troops, such the difficulty of arranging plans, that hitherto the taking of Matagorda had been the only check given to the enemy's works.

In July the British force in Cadiz was increased to 8,500 men, and Sir Richard Keats took command of the fleet; the French, intent upon completing their lines and constructing flotillas, made no attacks. The preparations at Matagorda constantly and seriously menaced Cadiz, and a British division was necessarily kept there; for the English Generals were well assured that some fatal disaster would otherwise befall the Spaniards. Graham's Division might have been set free instead of being cooped up without any counterbalance in the number of French troops employed to blockade. The latter aided indirectly, and at times directly, in securing Andalusia, and if not at Chiclana, must have been covering Seville as long as there was an army in the Isla; but Graham merely defended Cadiz.

In November, 1810, while the Spaniards were entirely occupied with the debates in congress, the French works were finished: their chain of forts was completed, each fort having a ditch and palisades with a week's provisions. Soult came to San Lucar, and his flotilla there and at Santa Maria, Puerto Real, and Chiclana, being all ready for action he proceeded to concentrate. On the last night of October 30 pinnaces and gunboats, slipping out of the Guadalquiver, eluded the allied fleet, passed along the coast to Rota, and from thence, aided by shore batteries, fought their way to Santa Maria and the San Pedro River. But to avoid the danger of doubling Matagorda the vessels were transported overland on rollers, and 130 armed vessels and transports were thus safely assembled in the Trocadero Canal. At the Trocadero Point there were immense batteries, and some notable pieces of ordnance, invented by Colonel Villantwys, called cannon-mortars. These huge engines, one of which was afterwards placed in St. James's Park, were cast at Seville, and being placed in slings, threw projectiles over Cadiz, a distance of more than 5,000 yards. To obtain this flight the shells were partly filled with lead, and their charge was too small for an effective explosion, yet they alarmed the city and were troublesome to the shipping.

Soult's design was to ruin by superior fire the fort of the Puntales

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then to pass the straits with his flotilla, and establish his army between the Isla and the city ; nor was this plan chimerical, for on the side of the besieged there was neither conceit nor industry. New drafts made by Wellington had reduced Graham's force to 5,000 men, and in October the fever broke out ; but as Soult's preparations became formidable, reinforcements were drawn from Gibraltar and Sicily, and at the end of the year, 7,000 British, Germans and Portuguese were still behind the Santi Petri. To insure naval superiority, Admiral Keats drew all the armed craft from Gibraltar. To secure the land defence, Graham urged the Regency to adopt certain plans, and he was warmly seconded by Sir Henry Wellesley ; but neither their entreaties nor the inconvenience of the danger could overcome the apathy of the Spaniards ; their troops were wanting in discipline, clothing and equipment and only 16,000 men of all arms were effective on a muster roll of 23,000. The labour of the British troops far from being assisted was impeded, and December ended before Graham, after many altercations, could even obtain leave to put the interior line of the Cortadura in a state of defence.

When in February, 1811,* Graham knew that Soult had gone to Estremadura he undertook to drive Victor from his lines. Troops sailing from Cadiz were to disembark in rear of the French and be joined by the garrison of Tarifa under Major Brown and by 3,000 Spaniards from San Rouque under General Beguines. Contrary winds delayed the expedition, and the despatch vessels carrying counter-orders to Brown and Beguines being likewise retarded, those officers advanced, the first to Medina, the second to Casa Vieja. Victor got notice of the design and kept close in his works, until he heard of this failure in the combinations, when he sent troops to retake Medina and the Casa. At the same time 12,000 men from the Northern Governments reached him and his whole force being 20,000, he had 15,000 in the lines ; the remainder were at San Lucar, Medina, and other ports. This was known at Cadiz, but 10,000 infantry and 600 cavalry were again embarked, being this time to land at Tarifa, and march straight on Chiclana. General Layas was left in command of the Isla with orders to throw a bridge over the Santi Petri near the sea-mouth.

On the 22nd the British troops passed their port in a gale, and landed at Algescias, marched to Tarifa the next day, and were joined by the 28th Regiment, and the flank companies of the 9th and 82nd Regiments. Thus more than 4,000 effective troops including 2 companies of the 20th Portuguese, and 180 German hussars were assembled under Graham ; all good and hardy troops, and himself a daring old man and of a ready temper for battle. The Captain-General, La Peña, landed on the 27th with 7,000 Spaniards, and Graham to preserve unanimity ceded the command, although it was contrary to his instruction. Next day a march of 12 miles carried

* Official abstract of military reports MSS.

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them over the ridges which separate the plains of San Roque from those of Medina and Chiclana, and being then within 4 leagues of the enemy's posts the troops were reorganized. The vanguard was given to Lardizabal, the centre to the Prince of Anglona; the reserve, composed of two Spanish regiments and the British troops, was confided to Graham: the cavalry of both nations, formed in one body, was under Colonel Whittingham, then in the Spanish service.

Before this Beguines and the partidas had driven the French into Casa Vieja and Medina; but General Cassaque being reinforced had retaken both places and entrenched Medina, acting as a covering force to the river. Victor manned his works at Rota, Santa Maria, Puerto Real and the Trocadero, with a mixed force of Juramentados and regular troops; but he assembled 11,000 good soldiers near Chiclana between the roads of Couil and the Medina, to await the unfolding of the Allies' project which was not delayed.

La Peña having 12,000 infantry, 800 horsemen and 24 guns turned towards the coast and drove the French from Vejer de la Frontiera. The following evening he continued his movement and on the morning of the 5th after a skirmish, in which his advanced guard of cavalry was routed by a French squadron, he reached the heights of Barosa being then 4 miles from the sea-mouth of the Santi Petri. Then followed the bloody Battle of Barosa which is fully described in the XIIth book of Napier's *Peninsular War*. The battle lasted only 1½ hours, but 50 officers, 60 sergeants, 1,100 British soldiers, and more than 2,000 French were killed and wounded: 6 guns and an eagle, 2 generals, both mortally wounded, together with 400 other prisoners fell into the hands of the victors.

All the passages in this extraordinary battle were broadly marked, and La Peña's contemptible weakness was surprisingly contrasted with the heroic vigour of Graham whose attack was rather an inspiration than a resolution, so wise, so sudden, was the decision, so conclusive the execution.

After the Battle of Barosa violent disputes arose in Cadiz. La Peña in an address to the Cortes claimed the victory for himself; he said that the arrangements previous to the battle were made with the knowledge and approbation of the English General, and the latter's retreat to the Isla was the real cause of failure.

Graham incensed at this proceeding wrote a letter to the British envoy in which he exposed La Peña's misconduct: he refused with disdain the title of Grandee of the First Class voted to him by the Cortes, and when Lascy used expressions relative to the action personally offensive he enforced an apology with his sword. Having thus shown himself superior to his opponents at all points, the gallant old man relinquished his command to General Cooke, and joined Lord Wellington's Army.

(*To be continued*).

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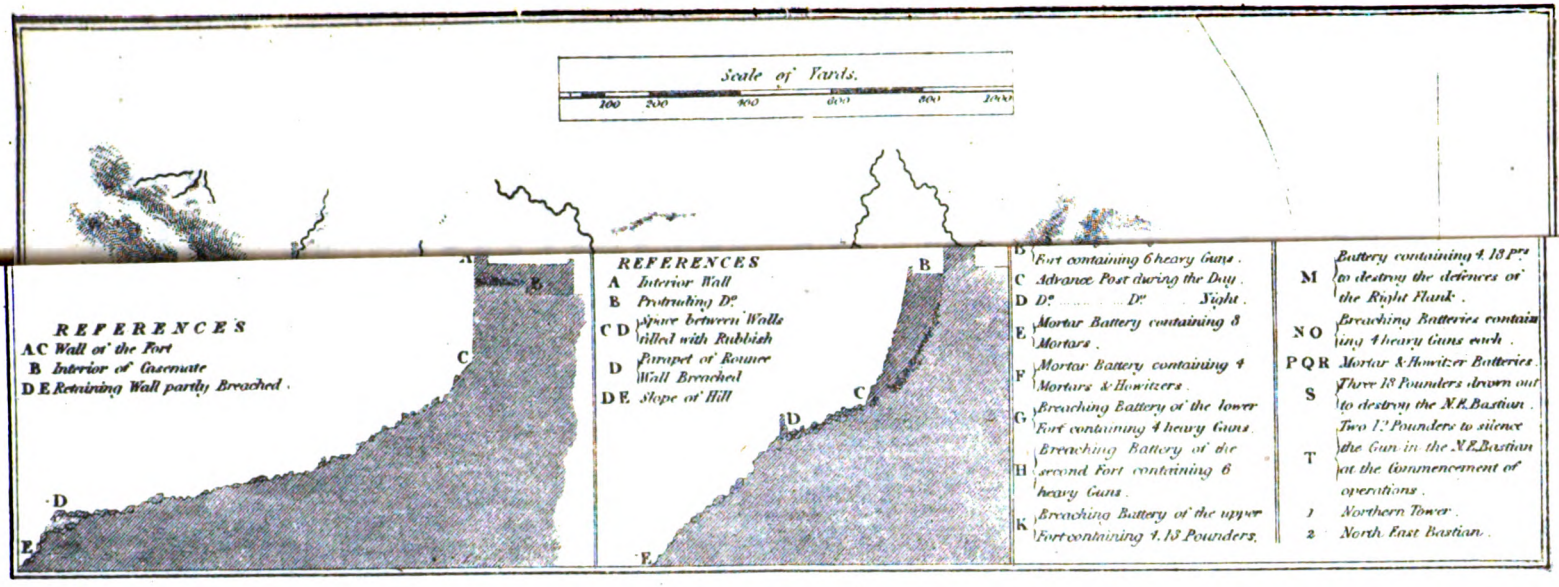
Scale of Yards.
100 200 400 600 800 1000
REFERENCES
AC Wall of the Fort
B Interior of Casemate
DE Retaining Wall partly Breached.
REFERENCES
A Interior Wall
B Protruding Dº
CD Space between Walls filled with Rubbish
D Parapet of Rounce Wall Breached
DE Slope of Hill
D Fort containing 6 heavy Guns.
C Advance Post during the Day.
D Dº Dº Night.
E Mortar Battery containing 8 Mortars.
F Mortar Battery containing 4 Mortars & Howitzers.
G Breaching Battery of the lower Fort containing 4 heavy Guns.
H Breaching Battery of the second Fort containing 6 heavy Guns.
K Breaching Battery of the upper Fort containing 4, 13 Pounders.
M Battery containing 4, 13 Pdrs to destroy the defences of the Right Flank.
NO Breaching Batteries containing 4 heavy Guns each.
PQR Mortar & Howitzer Batteries.
S Three 18 Pounders drawn out to destroy the N.E. Bastion.
T Two 12 Pounders to silence the Gun in the N.E. Bastion at the Commencement of operations.
1 Northern Tower.
2 North East Bastion.

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THE RELATIVE CARRYING CAPACITY OF RAILWAYS FOR TRAFFIC OF THE MILITARY TYPE IN WAR CONVEYED OVER LONG DISTANCES.

Based on a Lecture delivered at the School of Military Engineering, Chatham, 20th November, 1913, by W. TETLEY STEPHENSON, ESQ., B.A.

WHEN considering the carrying capacity of railways for traffic of the type that a railway must deal with in time of war, it is well to bear in mind that the traffic which is typical of our home railways is not of that kind. A much nearer parallel is to be found in the traffic handled by the great American railways. There traffic is dealt with in great bulk; trains loaded with a single commodity like wheat compose a large proportion of the trains on many railroads. The distances to be traversed are great, and these single commodity trains frequently run 1,000 miles or more to the ports without any change in the composition of the trains. Whether the distances were 500 miles or 2,000 miles would not be very material—once the distances are considerable the principles of working remain the same.

In dealing with the capacity of a railway in war, one has always to look at it from two points of view. An instance of a short-time point of view is given by the last rush of trains to Ladysmith before its investment. At such a time a number of trains may be passed over a line in a few hours by methods of working which would be wholly unjustifiable in ordinary working. Then there is the long-time point of view, when the question is more likely to become one of working the greatest amount of traffic over the line in a period lasting over weeks—possibly months. The problem was presented in an extreme form on the Trans-Siberian Railway in the Russo-Japanese War, and, wonderful as was the work accomplished by the engineering staff, the organization of the traffic working is open to much criticism. The capacity of a railway from the long-time point of view is mainly dealt with in the pages that follow, and must not be confused with the capacity of the railway for a very short time.

The first question usually asked about a railway is:—"What is its gauge?" Is the distance between the rails 5 ft. 6 in. or 4 ft. 8½ in. (the Standard Gauge) or 3 ft. 6 in., or some other width? This information is of very limited value by itself. Its greatest value lies in giving some idea of the opportunities of obtaining more rolling stock, often a matter of the greatest importance in war time owing to the rapid expansion of traffic calling for a large expansion in the rolling stock.

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In testing a railway's capacity the Loading Gauge is of really greater importance. Appended are some diagrams to show this. *Fig.* 1 relates to Standard Gauge line. The outer line defines

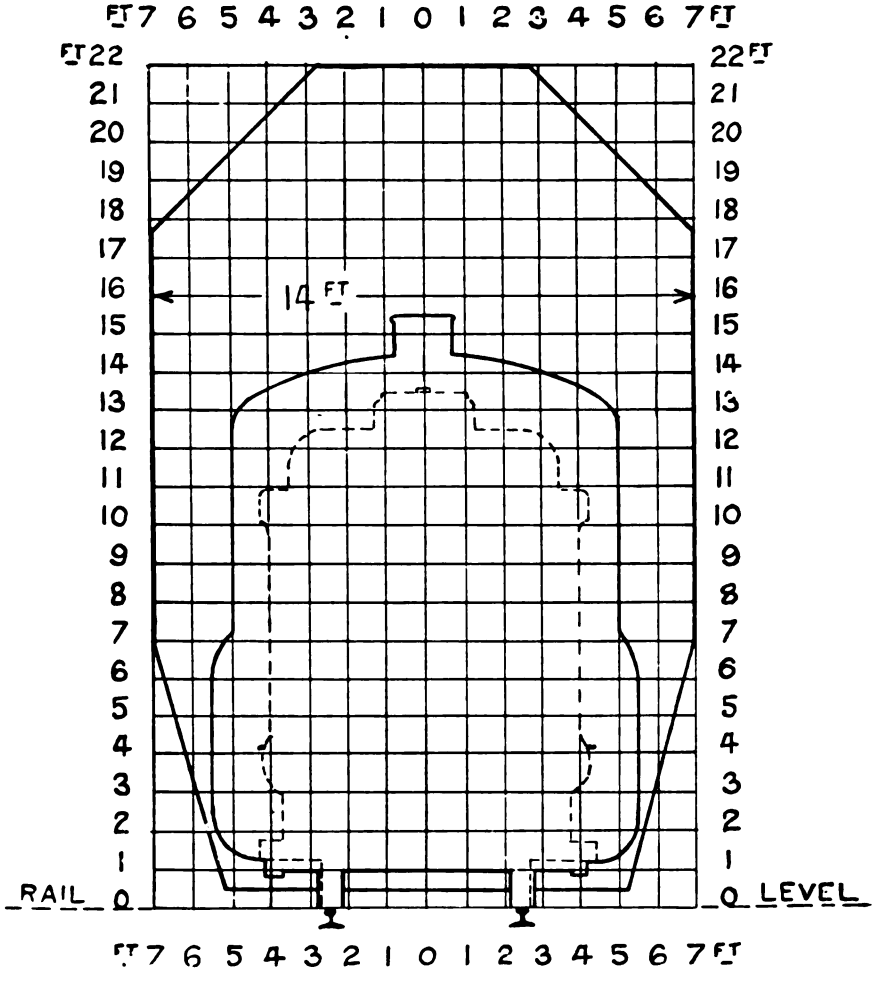

FIG. 1.—*Maximum Load Gauge, 4-ft. 8½-in. Line Gauge.*

the largest Loading Gauge to be found in the United States of America. It is exceptional even for that country, and full advantage of it is not taken. The Loading Gauges of large railways in this country vary somewhat, but a width of 9 ft. and a height of 13 ft. 6 in. at the centre above rail level may be taken as typical. The inner continuous line shows a cross-section of a typical large American locomotive, and its dimensions exceed in both width and height the English Loading Gauge dimensions. The broken line represents the biggest type of engine on the Great Northern Railway, and it is not only about as large as any in this country, but it is so

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large that the margin between it and the Loading Gauge is in places only a matter of inches. The bigger Loading Gauge allows the Americans to have locomotives of about double the power we can build. Wagons can be worked that are 1 ft. 6 in. to 2 ft. wider, which means, with other dimensions unaltered, a gain of 20 to 25 per cent. in carrying capacity. But the gain in height means a further addition and a wagon of the same length would be able to take 30 to 50 per cent. more traffic, whilst if absolutely full advantage were taken of the possible dimensions, the load would be double. Even as it is the difference in the dimensions of the Loading Gauges allows many United States railways to build locomotives and wagons which make it possible to convey three times the traffic load which can be taken by a similar train in this country.

Fig. 2 shows the limits of Loading Gauge for a 3-ft. 6-in. railway. In every direction the dimensions are in excess of

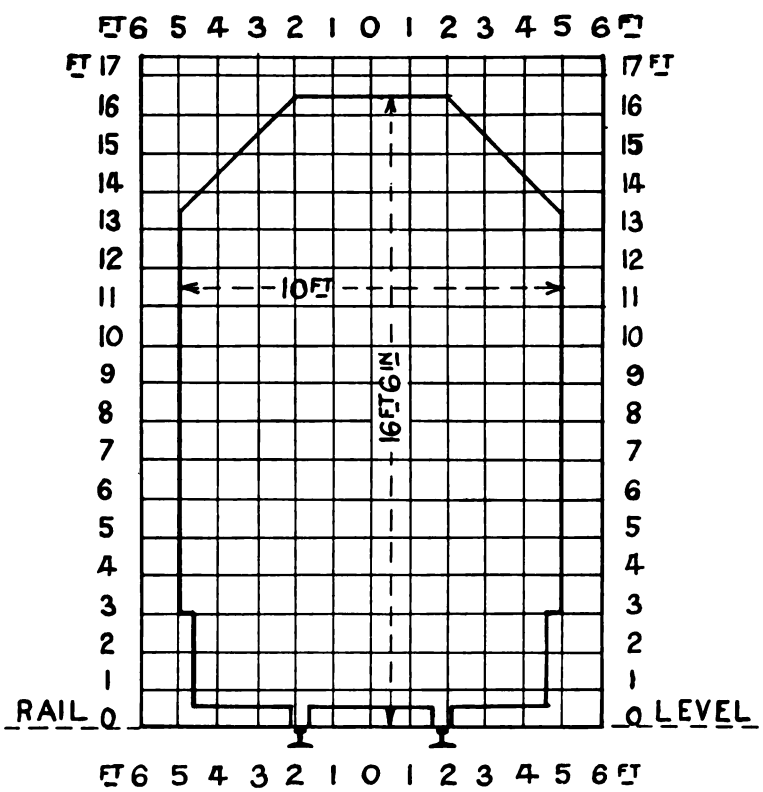

FIG. 2.—*Maximum Load Gauge, 3-ft. 6-in. Line Gauge.*

the Loading Gauge of our railways. Considerable advantage is taken of these limits. On the Rhodesian railways the width used is 10 ft. compared to our 9 ft., and the railways, not having platforms, the 10 ft. can be used as low as the wagon floor allows. It is not

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until 11 ft. from rail level that this width has to be reduced, and then only to 9 ft. 4 in.; still in excess of every English railway except the Great Western Railway. The maximum height allowable is 13 ft. 3 in. from rail level, which is about the average in this country. The advantages of our wider rail gauge are small. It costs more to construct and maintain, using more material and more labour. In working freight traffic we gain absolutely nothing. Our sole advantage is in connection with high-speed passenger trains; we can run our trains faster with safety.

A reference to Russian railways may be of interest. The gauge of these is 5 ft. 0 in., whereas "Standard" Gauge is the rule in all the neighbouring European countries. Has Russia one single advantage in peace or war for this to set against the extra cost? The writer fails to find one. Russia dare not make use of a larger Loading Gauge than the railways of Prussia, Hungary, etc., in case, in war, it should require to work its rolling stock over those railways. Russia also recognizes the great difficulties of widening the line gauge, and so goes to the expense of equipping its wagons with a device which enables them to work either on Russian or Standard Gauge lines. It is expense all the way, and not an item on the other side of the balance sheet worth mentioning.

Turning to the railways of a line gauge of 2 ft. 6 in. (*Fig.* 3)

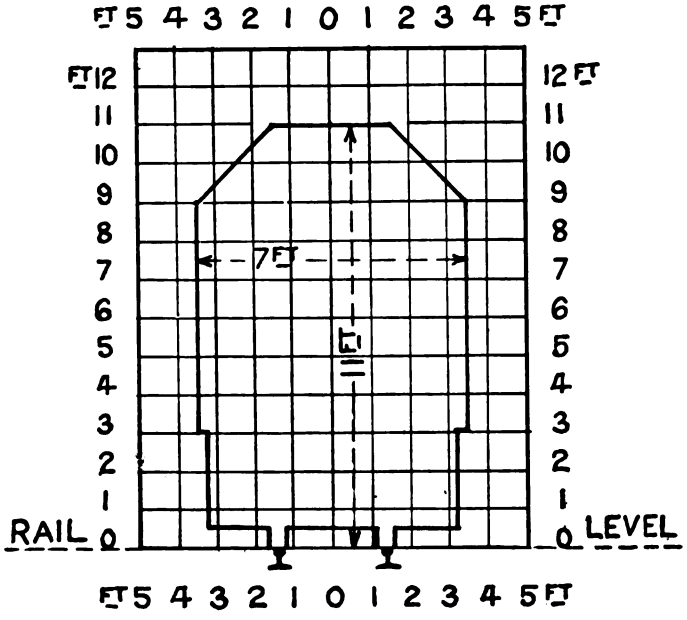

FIG. 3.—*Maximum Load Gauge, 2-ft. 6-in. Line Gauge.*

at last a gauge is reached which must have a smaller loading gauge than that used in this country. The position still, however, remains,

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that no comparison of relative capacity can be arrived at without the loading gauge being known.

A very rough rule is, that with varying line gauges and proportionate loading gauges the power of the locomotives can vary as the squares of the line gauges. The ratio of the traffic loads of the trains would be very much greater; probably the increase would be upwards of 50 per cent.

In practice a simple set of relations like this is rarely met with. Usually the narrow gauge railways have a relative advantage in loading gauge, but lose that and often much more through being planned with more severe gradients and sharper curves. The outcome is that though the locomotive is relatively more powerful for the narrow gauge line, the train which can be hauled is relatively smaller.

After the gauges, the next question is whether the line is double or single. The great mass of the world's railway is single line. In the United States, which alone possess more than one-third the railway mileage of the world, barely 10 per cent. of the mileage is double line.

Looking at single line first, the number of trains which can be worked over a line in each direction, provided rolling stock is adequate, depends upon the distance between the passing places and the way in which those passing places are laid out. In railway working all miles are not equal. One mile of railway is level and straight; another is on a steep up gradient; a third is on a falling gradient; another possesses curves of small radius. The result is that one mile will take two or three times as long for a train to run over it as another. Taking the Trans-Siberian Railway at the time of the Russo-Japanese War, a section measuring 7·6 miles on heavy up grade took the fastest train of the day 32 minutes. Whereas a section 8·9 miles, *i.e.* a $\frac{1}{6}$th longer, of undulating line took only 25 minutes. From a train-running point of view the first section was the longer. A little further on two sections, both $5\frac{1}{3}$ miles long occurred; one took 13 and the other 18 minutes to run. The distance between passing places requires to be measured by the time a train will take to run it rather than by the actual physical mileage. Moreover, if a single line is carrying the maximum number of trains, the capacity will be ruled by the section that takes the longest time, just as the strength of the chain is that of its weakest link.

Then as regards the accommodation at the passing places—this controls the size of the trains, and the number of trains which can be run. The Russians worked as large trains over the Trans-Siberian Railway as they could, but at some of the crossing places it was only just possible to get the trains inside by drawing the train forward until the brake van was clear inside, then fastening down the brakes on the rear wagons, and the engine shunting back

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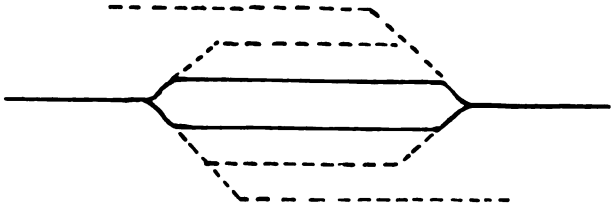
as to close up the couplings and get the wagons close together. This process occupied anything from 5 to 10 minutes, and was equivalent to lengthening the time the train took to run the section by that amount. Those crossing places not only limited the lengths of the trains, but reduced the number of trains it was possible to work over the line.

Then crossing places may only have accommodation for one train in each direction to pass at a time, or there may be additional sidings



or loops so that two or even three trains in each direction can pass one another. When sections are short such extra sidings are not of much value, but when sections are long they may be of great value as if trains are run in pairs a few minutes behind one another 60 per cent. more can frequently be run over the line in a given time. The Rhodesian Railway with crossing places 20 miles apart will serve as an instance. If trains were run at a speed of 20 m.p.h. including stops, it would be just possible to work 12 trains in each direction in 24 hours. But if two trains ran 10 minutes apart, and passed two others run in the same way, and if 5 minutes extra were occupied crossing the trains, two trains would be run in each direction every 2½ hours, or something over 18 trains in the 24 hours. If night working has to be prohibited, the relative figures become perhaps 6 against 10, and those extra trains might be invaluable.

If once the trains, which can be worked over a single line, exceed one per hour in each direction and the trains are of the heavy type, which should be run as far as possible for military traffic, it will hardly ever be necessary to trouble about the capacity of the railway to carry the number of trains required. Almost invariably it will be found that either rolling stock is short and more trains cannot be run for this reason, or station accommodation is insufficient and more train loads can be worked than can be dealt with at the stations. This is well illustrated by the German single-line railways leading to the French frontier. Although the length of single line is comparatively short, and the stations have been specially equipped for dealing with military traffic, the authorities only count on them as capable of dealing with a maximum of 20 trains each way in the 20 hours per day they would be worked. The lines ought to be able to carry at least 50 per cent. more trains in the time. The limiting

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factor is not really the train capacity of the lines, but the capacity of the stations.

With double line working the cases in which the train capacity of the lines is a limiting factor must be very rare. So long as the trains are run at a uniform speed and the line capacity is not wasted through running a few high-speed trains intermixed with trains of moderate and slow speeds, it will be possible as a rule to run trains at about 10-minute intervals. If there are long difficult gradients, 15-minute intervals might be necessary, but these are unusual. Generally 5 or 6 trains an hour should be reckoned on, and this means a number of trains which will tax the supply of rolling stock if distances are considerable, and even more will be likely to overtax the stations. To see the truth of this, it is only necessary to calculate the amount of rolling stock necessary if the journey takes 3 days out, 3 days back for the empty stock, and only a ½ day each end for loading and unloading. Let the trains be no more than 40 wagon trains. Each day 4,800 wagons will be used, and in 7 days, *i.e.* up to the moment the first returned wagon might be expected back, 33,600 wagons would have been used. This is a number greater by 4,000 than the total wagon stock of a great railway like the Union Pacific R.R., U.S.A.—the total length of which is about 7,200 miles. It would hardly be surprising if rolling stock ran short. Even more is the difficulty likely to be found at stations. The whole tendency is for military traffic to concentrate on some particular spot, just as in peace time traffic will concentrate on an exporting port. The difference is that whilst in the latter case the accommodation has been laid out to meet the estimated traffic, in the former there is only a short time for preparation. Even as it is, in the former case the capacity of double-line railway is so great that it would be easy to work into a place like Southampton Docks more traffic than the sidings could possibly provide for, and that undesirable condition of congestion could be reached before the conclusion of the first day. Again, it can be seen how the Germans interpret these conditions into numbers. In spite of special preparations, preparations which involve the provision of accommodation far in excess of commercial requirements, they count 60 military trains in 20 hours the maximum number for any double line, and the trains allotted to the frontier double lines vary from 40 to 50.

Over many double lines in peace time a far larger number of trains is run. But no comparison can be made between the ordinary trains which drop part of their load here, and part of their load elsewhere, or between the conditions which permit of a complete separation between freight and passenger traffic, and military trains in war time. Guns must accompany artillery; horses must go with cavalry; road vehicles must travel on the same trains as the men of the Army Service Corps. In this way freight and passenger

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traffic are combined, and the individual train requires a time at the terminal stations which is comparable to the freight train rather than the passenger train.

In ordinary peace-time working a double-line railway should be capable of dealing with four or five times the number of trains that a single-line railway can take; but when it comes to military traffic under war conditions, the double-line number drops to two or three times the single-line number. This ignores the capacity of the trains. How taking into account of train capacity alters the position may be illustrated by a comparison between the Southern Pacific Railroad of U.S.A. and our heaviest railways here. A few years ago, when the former was wholly single line, it was handling a freight traffic greater in density than the freight traffic of any of the lines here—all our main line is double track and much of it four-track road. The secret lay in the Southern Pacific's train load being at least five times the train load in this country. The difference in loading gauge and method of working were just balancing the difference between single line and double line.

Turning to other considerations, a few points of special interest only can be noted. First, I will pick out a couple of points in connection with locomotive working—the supply of fuel and water. For one large railway in this country, the freight engines burn on the average 85 lbs. of coal per train mile; so each ton carries a train only 26½ miles. When these engines are being worked with two shifts of men, they commonly burn about 6 tons in the two shifts. A hundred such engines are burning a train load, consisting of 60 wagons, each wagon carrying 10 tons. If a considerable length of line is being dealt with, and as many trains as possible are being worked, several train loads of coal for locomotive use may have to be worked daily. In this country it is not a very important matter because there are coalfields all up and down the country, and where there are not coalfields there are ports near to which coal can be brought for shipment. But in a country like South Africa, coal is found in Rhodesia and in Natal, and the Cape Colony ports, Cape Town and Port Elizabeth, are more than 1,000 miles away. Thus leads of 500 miles and upwards for locomotive fuel are quite usual. The locomotives required for the trains necessary for this work could ill be spared in war time. The occupation of the lines would mean an interference with military traffic, which would be undesirable. Every additional train which has to carry the fuel may mean one less military train. It is necessary to treat locomotive fuel as rather precious, and not to be lightly tampered with.

If fuel is of moment, water is of even greater importance. An engine commonly consumes an amount of water seven or eight times the weight of the coal burnt. If it burns 6 tons of coal, it will require 40 to 50 tons of water. So the carriage of water is a much more

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serious matter than the carriage of coal. On most railways it will be found that the supply of water for locomotives varies enormously. At some places it is superabundant, and under no conceivable circumstances is it likely to run short. At others the supply will be just sufficient for ordinary uses, and usually no more. Any draft on the latter places means a shortage which will bring engines to a standstill unless water is hauled. The shortage may be the more serious because all water is not suitable for locomotive purposes. For instance waters which produce a hard scale in the boiler are bad, and not only cause trouble on the road but increase the time engines must be laid off for cleaning and repairs. Then the military traffic may cause a big increase of traffic just where the margin of water is least, and, as the Russian railways found in the Russo-Turkish War of 1877–78, a shortage of water may actually limit the number of trains which can be worked. It is never safe to reckon on the trains which a line can carry until it has been ascertained that there will be a sufficient supply of water for the locomotives to run those trains.

Then earlier a reference was made to the likelihood of rolling stock running short and becoming the controlling factor. Even if it does not run short for military purposes it may make such trouble for the civilian population as to become a serious factor. In the Russo-Japanese War the amount of rolling stock drawn from European-Russia was responsible for famine, and at the same time grain lay rotting at other stations for lack of rolling stock to carry it. Organized control of the movement and use of the rolling stock is most important, and that control should concern itself with the empty vehicles as much as with the loaded. It is one thing to have plenty of empty wagons on a railway, and quite another to have those same wagons where they are wanted at the time they are wanted. It is important to realize to what a large extent wagons must be moved about empty to reach places where there are loads for them. On very well-regulated railways, with a well-distributed traffic, some 30 miles have to be worked empty out of every 100 miles worked loaded and empty when general merchandise is the traffic. When the traffic consists of minerals the proportion is 47 or 48 empty out of every 100 miles worked. Now what applies to mineral traffic in this country applies generally to traffic worked in large quantities over long distances. In war time military traffic flows almost wholly in one direction. If then empty wagons are not returned promptly a shortage is most likely to occur.

But organized control is necessary from every point of view. A very old practice was to paint a permanent instruction on the sides of many vehicles "When empty return to Station A." In the absence of adequate organized control this was very necessary, but it was very wasteful. A wagon would be 10 miles from a station

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needing one of the kind, but being marked for a station 100 miles away it would duly go away empty, whilst the station in need waited for the return of another wagon from an equally long distance. Waste of time to the traffic, waste of wagon time, waste haulage. In France to this day many wagons are still marked in this way, and in the case of a mobilization loss of valuable time might ensue in carrying out the work of getting the labelled wagons to their home stations. An organized system of control, under which a few district controllers, under a head controller, have daily full particulars of the positions of all wagons available for loading, does away with this waste, and experience has proved such control may result in 10 per cent. more use being got out of a given stock of wagons.

A few only of the many considerations which have to be taken into account have been noticed. Others fall into various groups. There are engineering matters, like the strength of the permanent way: there are matters of organization, like the prompt loading and unloading of wagons. These and many similar matters have a great influence on the rapidity with which a mobilization or concentration of forces can be carried out. It is only after each and all have received their due share of attention that the capacity of a railway for military traffic in war time can be gauged.

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A NEW METHOD OF MEASURING IMPACT.

By MAJOR D. BRADY, R.E.

A PAPER of great interest by Major B. Hopkinson, Cambridge University O.T.C., R.E. (T.), better known as Professor Hopkinson, F.R.S., on " A Method of Measuring the Pressure produced in the Detonation of High Explosives or by the Impact of Bullets," is published in the *Transactions of the Royal Society*. Its reference number is A. 506, 31st January, 1914.

The author explains how a blow on one end of a bar is transmitted to the other end as a ripple of pressure, and returns as a ripple of tension. The whole momentum due to the blow lies in the part of the bar under the ripple. The length of the ripple is a measure of the duration of the blow, and its shape—supposing it is plotted—indicates the character of the blow.

Suppose the ripple is 10 in. long—which in steel represents a duration of about $\frac{1}{20000}$ second—and suppose there is a butt joint unable to resist tension not more than 5 in. from the end of the bar. While the ripple is being reflected, all the pressures pass forward through the joint, and all the tensions pass back through it. There must come an instant when some tension going back through the joint just equals some pressure going forward. The piece then flies off carrying with it whatever momentum is included in the central part of the ripple between equal ordinates of stress. If the piece is, say, 4 in. long, the equal ordinates are 8 in. apart ; if the piece is 5 in. long it carries off the whole momentum due to the blow.

By repeating the experiment with different lengths in front of the joint, the momentum of each corresponding length of the ripple is found, and a great deal about the ripple, and therefore about the blow, is disclosed. The only thing not disclosed is whether the ripple leans forward like a wave about to break, or leans back, or leans neither way. If that information is worth getting, it might be possible to get it by repeating the experiments after arranging that the joint shall break at a definite tension, instead of being unable to resist any tension.* The parts of the ripple measured would then lie between ordinates having a definite difference, and a comparison of the two sets of experiments would give the missing information.

* [The author makes no mention of this, and it would probably be very difficult to do.—D.B.].

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The author's apparatus is very simple. A steel bar about 4 ft. long is slung horizontally. Different thicknesses were used, but most of the rifle shots were fired at a bar 1 in. in diameter. One end of the bar receives the blow, at the other end, against a carefully scraped surface, pieces of different lengths can be fitted. As the pieces are shot off they are received by a ballistic pendulum. The bar acts as its own pendulum to register the momentum left behind by the detached piece. To hold the pieces in close contact with no unnecessary force a solenoid was used to magnetize the bar and piece.

Professor Hopkinson made a great number of experiments with the old ·303 Service bullet, and made some experiments with a 1-oz. primer of gun-cotton. He was compelled to keep the gun-cotton $\frac{3}{4}$ in. clear of the bar, as the steel would not stand a closer blow. The Service bullet gave a pressure of about 19 tons as a maximum, and the whole impact lasted about $\frac{1}{17000}$ second. This duration is, as it should be, approximately equal to the time taken by the bullet to travel its own length at 2,000 ft. a second. The pressure $\frac{3}{4}$ in. away from a 1-oz. gun-cotton primer averaged about 30 tons a square inch for $\frac{1}{100000}$ second, and probably reached a maximum of about 40 tons. Within about $\frac{1}{50000}$ second the pressure falls to less than one-fifth to that. The way gun-cotton breaks steel before there can be much deformation is clearly shown by some examples, one of which shows quite a lot of deformation that must have happened *after* the break.

The discussion of the method and its possible errors is of great interest.

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BAIRD SMITH PAPERS DURING THE INDIAN MUTINY.

AMONG the many interesting Corps documents which have found their way into the R.E. Museum during the last two years, there are few of greater historical interest than those of the late Colonel Baird Smith which have recently been presented to the Corps by his two daughters. These include not only several personal diaries, reports, etc., but also the original Engineer diary of the Siege of Delhi, a rough tracing of the City that was issued to Brig.-General John Nicholson on the eve of the assault and which shows the routes to be taken by the assaulting columns; the letters and memos sent by Major-General Archdale Wilson to Colonel Baird Smith during the siege, and the final despatch submitted by the C.E. to the General after the capture of the City.

In the present *Journal* it is proposed to print a most interesting letter written by Colonel Baird Smith to Mr. C. E. Norton, giving an account of the mutiny of the Sappers at Roorkee: also Colonel Baird Smith's official account of the steps taken at Roorkee for the protection of the European community there.

From the letter it will be seen that the original mutiny of the Sappers at Meerut was apparently due to a misunderstanding, and that although their action led to the mutiny of the remaining companies at Roorkee, the latter was attended with no violence, and the officers and other Europeans were treated with courtesy and consideration by the men of the Corps.

(1).

Letter from Colonel Baird Smith to C. E. Norton, Esq., of Cambridge, Massachusetts, U.S.A.

ROORKEE, *30th May*, 1857.

MY DEAR CHARLES,

I write to you in the midst of all the turmoil of a state of war at our own doors and it is among the possibilities, tho' please God not among the probabilities of the future, that I may never write to you again. A fortnight ago no community in the world could have been living in greater security of life and property. Clouds there were that indicated to the thoughtful minds a coming storm and that, in the most dangerous quarter, but the actual outbreak was the matter of an hour, and has fallen upon us like a judgment from Heaven, sudden, irresistible as yet, terrible in its effects, and still spreading from place to place. I daresay you may have observed among the Indian news of late months that here and there throughout the country mutinies of Native Regiments have been taking place.

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They had, however, been isolated cases and the Government thought it did enough to check the spirit of disaffection by disbanding the Corps involved. The failure of the remedy was, however, complete, and instead of having to deal now with mutinies of separate Regiments we stand face to face with a general mutiny of the Sepoy Army of Bengal, and to those who have thought most deeply of the perils of the English Empire in India this has always seemed the monster one. It was thought to have been guarded against by the strong ties of mercenary interest that bound the Army to the State and there was probably but one class of feelings that would have led to these being too weak to have this effect—the feelings of religious sympathies or prejudices. The overt ground of the general mutiny is offence to caste feelings shown by the introduction into the Army of certain cartridges said to have been prepared with hog's lard or cow's fat. The men must bite off the ends of the cartridges so the Mohammedans are defiled by the unclean animal and the Hindoos by the contact with the dead cow. Of course the cartridges are *not* prepared as stated and they form the mere handle for designing men to work with. They are I believe equally innocent of lard and fat, but that a great deal of dread of being Christianized has by some means or other been created is without doubt, tho' there is still much which is mysterious in the process by which it has been instilled into the Sepoy mind and I need not trouble you with mere rumours of explanations as I question if the Governor has any accurate information on the subject.

It was on the 10th of the present month that the outbreak of the mutinous spirit took place in our neighbourhood. The locality was Meerut. The immediate cause the punishment of 85 troopers of the 3rd Light Cavalry who had refused to use the noxious cartridges and had been sentenced by a Native Court-Martial to 10 years' imprisonment. On Saturday the 9th the men were put in irons in the presence of their comrades and marched off to jail. On Sunday the 10th, just at the time of Evening Service, the mutiny broke out. Three Regiments left their lines, fell upon every European, man, woman or child, they met or could find, murdered them all, burnt half the houses in the station, and after working such a night of mischief and horror as devils might have delighted in, marched off to Delhi *en masse* where three other Regiments ripe for mutiny were stationed, and on the junction of the two Brigades, the horrors of Meerut were repeated in the Imperial City and every European who could be found was murdered with revolting barbarity. In fact the spirit was that of a servile war. Annihilation of the ruling race was felt to be the only chance of success and impunity, so no one of the race was spared. Many however effected their escape and after all sorts of perils and sufferings succeeded in reaching military stations having European troops. Many of my own officers I am thankful to say

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were of this number. Young Thomason, a son of the late Lieut.-Governor and in this department, got safely to Kurnaul after a week's wanderings on foot—he was engaged to be married to a Miss Jennings, the daughter of the Chaplain of Delhi. Father and daughter are among the murdered and Thomason's dream of life has a heavy darkness over it. Stewart Rigby (?) Parker, Anderson Marshall, all canal men, had some to flee, some to fight for their lives, and are all safe. The works generally are cruelly damaged, but we shall soon put them to rights.

It was on the 12th at daybreak that I received the first intimation of the Meerut Mutiny and Massacre. When I went to the porch of my house to mount my horse for my morning ride I found Medlicott, our geological professor, sitting there looking oppressed with some painful intelligence, and on my asking what the matter was he then told me that about an hour before Fraser, the Commandant of the Sappers and Miners, had received an express from the General at Meerut ordering him to proceed with the Regiment by forced marches to that place, as the Native Regiments were in open revolt, and had left Cantonments with their arms. Not a word was told but even the bald statement was alarming enough. I immediately suggested the Ganges Canal route instead of forced marches, which would have fatigued the men much and made them unfit for service, and as Fraser at once agreed I had boats equal to the transport of 1,000 men ready within 6 hours and the Corps 713 strong, started the same afternoon and got to Meerut 60 miles off in about 24 hours. Just as they were starting another express came to say that two companies were to be left for the protection of Roorkee, so that finally about 500 men moved. I sent off the same morning an express to the Commandant of the little Ghoorkas at Deyrah to tell him I thought his Corps would be ordered down too, and begging him to march on Roorkee where I would have another fleet ready for him in a day or two. He came with his almond-eyed Tartars in due course, and off they went too. Then came the news of the Delhi massacre, and it became necessary for me to provide for the security of our little community here. I had indeed begun to do so from the day the Sappers left, and had determined that the Workshops were to be our Citadel. Here I had got the Superintendent quietly to begin equipping 3 cannons, and had planned the defensive works that would have to be executed. I had also organized an Intelligence and Commissariat Department, so that when the time came to occupy the place all preliminary arrangements had been made. This we did on the 16th when the women and children, then exceeding 100 in number, were moved into the workshop rooms and all decently accommodated there. The males were about the same number but chiefly clerks and the like, so unaccustomed to arms. We had however about 30 trained soldiers and 8 or 10 good

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officers, and on them my main reliance was. However such as the force was, it was organized into guards, placed under Commandants and formed into a manageable body. Our two companies of Sappers proved an embarrassment rather than a source of strength. They were all Natives and we had reason to know that the prevailing spirit of disaffection had in some measure tainted them, and although I personally believed that the main body was entirely worthy of trust, still there was much uneasiness about them. I put them however under the command of two officers well known to them, spoke to the best men among them myself, gave over to their charge all the College Buildings and could do no more. Thus matters continued until the 18th on the afternoon of which day it was reported to me that extreme excitement prevailed among the men of the Sappers and that some Sepoys of the Corps had come in from Meerut and reported that the Regiment had mutinied there, killed poor Fraser and been immediately attacked by the Europeans and destroyed by grape from the guns. One company had marched the night before with the Engineer Park to join the Commander-in-Chief and the detachment with us was reduced to about 190 to 200 men. I believed the report to be a device of the enemy having had letters from Meerut on the 16th (the day of the reported catastrophe); these I sent to the Cantonments and begged the officers to explain them to the men and to keep them quiet. The day however was one of intense anxiety as a struggle between 20 or 40, and even 200 trained and educated soldiers like the Sappers was rather a serious contingency to anticipate. All sorts of wild rumours were flying about . . . In the evening it was reported to me that the company which had marched the previous day had been overtaken by the men from Meerut, had mutinied on the spot, refused to move forward and insisted on returning to Roorkee to rejoin their comrades. The report added of course that they were resolved to attack us, burn Roorkee and kill every European in it. Of this however I had comforting doubts when I learnt that the men were accompanied by their European officers, not one of whom had been injured or insulted. I sent out a party to observe the movements of the Company, and I had settled in my own mind that if it meant mischief, it would march on to Roorkee Bazaar, if not, by a road that leads to their own lines, and you can scarcely fancy the relief it was to me to hear from my scouts that the Column was moving by the latter. It was a small straw that gave me some light as to how the wind blew, and for the moment I felt certain no collision with us was in contemplation. I was of course on foot the whole night, the garrison was kept to its arms, guns loaded with grape and everything ready for a stiff struggle, if struggle there was to be. At midnight the officers of the Roorkee Sapper Detachment came in to tell us that their men refused to obey them any longer, but had

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sent them away not only with courtesy and kindly personal feelings, escorting them out of Cantonments and protecting them against the few bad characters who were disposed to injure them. About 1 a.m. the officers of the returned company also reported themselves to me, and it then became evident that our Mutiny was to be distinguished honorably from those which had preceded it by the absence of all atrocity towards Europeans, as the whole body consisting of 6 officers, 6 sergeants, 6 women and 5 children were now safe within the Workshop walls. Then came the question—What next? I had all along felt satisfied that the main body of the men were mutinous from fright and distrust, not from disaffection to the State, and I was not unprepared to hear as I did about 3 a.m. that they were in mortal terror of my attacking them at daybreak with the guns and were running away in confusion as fast as they could. The moment the light did break I sent a strong body of Europeans under Maclagan to clear the lines, and when they reached them they found them tenanted by about 40 Sepoys only out of 300, and these declared that they had no other wish than to serve the Government faithfully. The rest were clean gone, some across the Ganges, others to Delhi, but near us they have come no more. And so this, the darkest cloud we had over us, burst and passed away without one flash of forked lightning. My heart never beat more lightly than when a report came back from the Cantonment that the Mutineers were then 10 miles off. In the course of the 19th authentic intelligence was received of the dispersion of the Corps at Meerut, of poor Fraser's death, and of the safety of the other officers of the Corps. So far as I can offer an opinion want of judgment on Fraser's part brought on the catastrophe. He had promised the men that they should keep their own magazine, and meant of course that they should do so, but he wanted for better security to put it in a bombproof building and ordered its removal without having the object fully explained to the men. They suspected treachery and stopped the carts—he abused the men who did so—an Afghan sentry then shot him in the back—another shot the Native N.C.O. with him, some others fired at Maunsell, the Adjutant, but missed him. Then the guns opened on the Corps and scattered it, and the Carabineers charged the fugitives and killed about 50 or 60 of them and the Corps of Sappers and Miners ceased to exist.

From this crisis our local anxieties have lessened. But the country around is in utter confusion—bands of robbers are murdering and plundering defenceless people—Civil Government has practically ceased from the land. I have not heard *one word* from the Lieut.-Governor since this disastrous time began. A full month will elapse before the Mutineers are checked by any organized resistance. A force is or is supposed to be marching on Delhi but the outbreak occurred on the 10th of May and this day is the 1st of June and

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Delhi has seen no British Colors and heard no British guns as yet. I am sick to death of a military system so feeble as ours and against it at any rate am mutinous to the core. As to the Empire it will be all the stronger after this storm, and I have never had a moment's fear for it. It is not 5,000 or 6,000 mercenaries or ten times that number that will change the destiny of England in India, and tho' we small fragments of the great machine may fall at our posts, there is that vitality in the English people will rebound from misfortunes and build up the damaged fabric anew.

At this place we are all in high spirits. We are respected and somewhat feared. Plunderers avoid us because they know they will be attacked. We have confidence growing round us daily and our Bazaar is full and the people contented.

Yours, etc.,
R.B.S.

To C. E. NORTON, ESQRE.,
Cambridge, Massachusetts, U.S.A.

(2).

Report of Proceedings at Roorkee during the Disturbances of 1857 *and* 1858.

By LIEUT.-COLONEL R. BAIRD SMITH, C B.

THE following Narrative is prepared in conformity with the orders of the Right Hon'ble the Governor-General as given in Circular No. 212, dated 30th April, 1858.

The state of feeling in the Native Army out of which the mutinies grew was first brought directly under my personal notice at the instance of certain enterprising merchants of Meerut and Delhi who, availing themselves of the facilities for transit supplied by the Ganges Canal, had entered into large speculations in grain for the supply of the Military Bazaars at Futtygurh, Cawnpore, Mynpooree, etc. The grain was ground into flour at the Canal Mills and transported in boats to the points nearest to the stations mentioned. Under date the 24th April, 1857, the Native Agent of the Navigation Department at Cawnpore forwarded to Mr. James Finn, the Superintendent, a report stating that provision had been made for the transport of 1,000 maunds of flour to Cawnpore, of which 200 maunds had arrived and been offered for sale, that evil-disposed people had however spread a report among the Sepoys that in grinding the grain at the Canal Mills the bone dust of cows and swine had been mixed with the flour by order of Government, and with the object of defiling Hindoo and Mahomedan alike, that much excitement had been created and none of the flour sold, he therefore requested instructions how he was to act. He was informed in reply, that the Canal Officers had no concern either with the mills or the grain

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ground in them, that they were entirely in the hands of native contractors with whom the proprietors of the grain made their own arrangements, and that the report of any interference of Government with the purity of the flour was false, that he might give this assurance to all requiring information, but no further steps need be taken in the matter.

On the same date that the above circumstances were reported to me, I sent details of them to the late Mr. Colvin, who concurred with me in thinking that any further official interference would not be expedient. I certainly did not attach much significance to the occurrence at the moment, and as it was known to me that the merchants had themselves superintended the grinding of the corn, I considered them to be the best agents to trust to for the removal of the prejudice against it. It was all disposed of ultimately, but not to the Sepoys.

As the merchants engaged in these transactions had meant to carry grain to all the important cantonments in the Dooab, and had actually made considerable purchases for the purpose, I think it is a fair inference that they were entirely ignorant of any organized or extensive conspiracy against the Government. Considering the ordinary caution of native traders, it seems incredible that they would have staked eight or ten thousand rupees in speculations of which the failure was inevitable in the event of such a conspiracy breaking out. Although therefore these men may have been conscious of the general feeling of distrust and alienation between the Government and the European Community on the one hand, and the Native Army on the other, yet it has always been my impression that the actual outburst of the Mutiny took them and their class almost as much by surprise as it did ourselves.

In relation to the same point, I may mention here that almost up to the date of the outbreak, village communities along the line of the Ganges Canal were spontaneously entering into contracts for water to extend over three years and taking upon themselves considerable pecuniary obligations connected therewith. After much enquiry among Native Officials whose subsequent conduct has placed their fidelity to Government beyond all question, I have been wholly unable to discover any satisfactory proof that the agricultural class with which this Department is so intimately connected had any knowledge that so terrible a convulsion as the Mutiny was impending.

So far therefore as the conduct of the Commercial or Agricultural classes came under my own observation, or was open to my enquiries, it has led me to believe that as great classes they had no share in the machinations out of which the outbreak arose but to the day of its occurrence were occupied with their own interests and work.

It was before daybreak of the 12th of May, 1857, that the first

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intelligence of the Mutiny of the 10th at Meerut, and its disastrous results reached this station. It came in the form of an express message from Major Waterfield, Assistant Adjutant-General, to Captain E. Fraser, Commandant, Sappers and Miners, directing the latter officer to proceed with his regiment by forced marches to Meerut as the whole of the native troops were in open mutiny and were then supposed to have marched to Delhi with their arms. The message was communicated to me at day break, and I then suggested to Captain Fraser that instead of proceeding to Meerut by forced marches and thus arriving with officers and men fatigued, it would be both quicker and better to drop down the Ganges Canal. This being agreed to, measures were at once concerted with Mr. James Finn, the Superintendent of Navigation for collecting the boats required, and by this officer's indefatigable exertions the whole number necessary for the regiment was equipped by noon.

Meanwhile, a second message had arrived from Major Waterfield conveying Major-General Hewitt's orders for two Companies to be left in the cantonments at Roorkee, which was accordingly done, and at 2 p.m. of the 12th, the Head-Quarters, and six Companies embarked with all their baggage and reached their destination in due course.

After seeing the preparations for the Sappers fairly in progress, I wrote to Major Charles Reid commanding at Deyrah to give him the intelligence of the mutiny and to say that as I thought it probable his corps would also be ordered into Meerut, I would have boats, sufficient for the transport of 1,000 men with their baggage ready within 48 hours, and begged him if so directed to march on Roorkee and proceed from thence by water carriage to Meerut. This letter, sent express, gave the first intelligence of the mutiny at Deyrah, and Major Reid at once agreed to the arrangements proposed should the Sirmoor Battalion receive orders to march.

Having thus disposed of matters connected with the movement of the only two regiments in this neighbourhood, it was necessary next to consider the position of the European community at Roorkee and the best means of providing for its security. Though far from anticipating at that moment the universality of the revolt, it was impossible to consider the successful mutiny of three Regiments, the march of the mutineers upon Delhi with its probable results, and the events of the preceding three months at almost every large military station in this part of the Country, without feeling the gravest apprehension for the issues that might follow. It seemed to me therefore prudent and right that the worst should be anticipated and provided for though possibly enough it might never happen.

The condition of the community here at the time of the Mutiny was certainly as defenceless as it well could have been ;—numbering in all about 200 souls, of whom about 90 were males fit to bear arms, and the remainder females and children, it did not include more

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than about 30 trained soldiers of whom not one-fifth had ever seen any service. The rest of the men were assistants and clerks in the Civil offices at the Station or connected with the Thomason College; all lived in houses scattered over a large area forming the Military Cantonment and Civil Station, and the only arms and ammunition available at the moment were 30 stand with 30 rounds for each which had been supplied to Captain Maclagan by Captain Fraser for the use of the soldier students of the Thomason College on the departure of the Sappers and Miners for Meerut.

Considering the circumstances above described it seemed that the safety of the community would be best secured by providing a defensible post sufficiently large to contain the whole; by arming and strengthening the same, in such ways as were possible; by supplying it with provisions; by organizing a good system of intelligence, and having the different roads of approach to the station watched; and by obtaining a reserve supply of arms and ammunition sufficient for the whole of the male inhabitants at the place.

In the workshops at Roorkee we possessed a place with considerable capability for defence against Infantry, or against any *Coup de Main*. They were quite untenable against Artillery, as the enclosing walls were too weak and thin to stand the fire of even the lightest Field Guns, but it was hoped that Artillery would not be brought against them, and on the whole they formed a far better post than any other large building at our disposal. I determined therefore at once to prepare them for the reception of the community.

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From a desire to avoid any unnecessary or premature alarm, I gave my instructions confidentially to Lieutenant Baillie, Superintendent of the Workshops, and Mr. James Finn, Superintendent of Materials, to whom the charge of the Commissariat and Intelligence Departments was entrusted; and most admirably were they carried out by both these gentlemen.

Among the materials for the use of the foundry in the shops were some old Sikh guns, the spoils of the Punjab Campaign, much the worse for wear but still not unserviceable. Three of these were selected and Lieutenant Baillie proceeded at once to construct carriages for them. They were of old French pattern and just too small for six-pounder balls, but this difficulty was got over in the first instance by preparing only grape and canister, and afterwards by casting balls specially for them.

By night fall of the 12th all needful arrangements had been decided on, and a beginning made in carrying them into effect. The 13th passed quietly over without our receiving any further intelligence from any quarter of the progress of the Mutiny, and with no signs of disturbance or bad feeling among the sepoys in cantonments.

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But about 1 A.M. on the 14th I was roused from my bed to receive a report that one of the barracks for the soldier-students of the College was on fire, and I proceeded at once to the spot. By the time I arrived the roof was burning fiercely. Happily there was little or no wind and the light gusts that occasionally rose came from the East and carried the flames and sparks away from the mass of buildings, all thatched, forming the barrack-square. It was doubtless to this circumstance that the escape of the other buildings was due. The fire engines were in full work when I arrived, the Sappers had been brought down from their lines and were working the engines apparently with good will and zeal. All efforts to extinguish the fire were however useless and the main object was to prevent its spreading. This was effected and the damage done was limited to one barrack.

On considering the circumstances connected with this fire so far as they could be ascertained, it was quite clear to me that it was not accidental, and the painful conviction was felt that we had among us the same destructive and mutinous spirit that had shown itself in like forms at other stations. All sense of security for property was at an end, and it only remained for us to take instantly such precautionary measures as were in our power. In the course of the 14th, therefore, the soldier-students of the College were armed and formed into a guard having its head quarters at the Model Room in the Workshops. A party of officers undertook mounted patrol duties, and from that time forward the Station was traversed at uncertain hours of the night by guards of horse or foot. No further attempts at arson were ever made, and the single barrack destroyed represents the whole loss to Government from the mutiny at this Station.

On the 15th I received orders from the Commander-in-Chief to assume Military Command of the place and to detach at once to join his camp one of the two Companies of Sappers left here, forwarding with them a considerable convoy of Engineer Stores. Measures were at once taken to give effect to these orders.

It had now become necessary to obtain, by some means or other, arms and ammunition for the main body of the community who were found to be almost entirely destitute of them. If our guns were to be of any use to us, powder for them, of which we had not a grain, must also be obtained. In the magazine of the Sappers about 200 stand of spare arms, considerable quantities of spare musket ammunition, and about 211 barrels of Ordnance powder used for mining practice were stored, and of these I determined to take possession. But before doing so, and with reference to the conviction which the recent case of arson had created regarding the state of feeling among the men, it seemed to me expedient first to attach some officers to the detachments, on whose firmness, dis-

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cretion, and personal influence I could rely. With this view I appointed Captain Drummond, Superintendent, Northern Division Ganges Canal, who formerly had charge of one of the companies and knew all the older soldiers in it, to command the detachment, and Lieutenant Bingham, Head Master of the Thomason College, who had been for 20 years in the corps and was universally respected by the native officers and soldiers, to act as Adjutant. Both officers moved into the Lines and resided there permanently.

Orders were then sent to Mr. Conductor Smith in charge of the Magazine to send down the arms, ammunition and ordnance powder to the workshops, and Lieutenant Baillie was instructed to despatch carriage at once for them. The first set of carts were loaded and despatched without the slightest difficulty. The men seemed at first to consider the matter as one with which they had no concern, and a fair supply for the Garrison was securely lodged in a temporary Magazine that had been prepared in the shops.

On the second set of carts being loaded however a change had come over the feelings of the men. They turned out tumultuously, and refused to allow any more arms or ammunition to leave their magazine. As night had fallen I directed the carts to be left at the quarter guard, and next morning I rode up to the lines unarmed and accompanied only by Captain Drummond, and sending for the Native officer who came, and accompanied by a considerable body of Sepoys, we sat down in the quarter guard and explained the objects for which I wanted the arms and powder. By this time rumors of large gatherings of Goojurs and other marauding tribes of which this neighborhood is a principal seat, had become very rife and I placed my desire to have arms for the Europeans chiefly on the ground of necessity for being prepared against such attacks. The men were all perfectly civil and respectful and the conversation ended in their withdrawing all opposition to the removal of the carts, which accordingly reached the workshops in the course of the morning, and all anxiety regarding a sufficient provision of arms and ammunition was at an end.

Satisfactory progress had by this date been made in preparing the workshops for occupation, arrangements for supplies of provisions had been completed, and every road leading to the station was well watched.

On the 16th the intelligence of the occupation of Delhi by the Meerut mutineers and its terrible consequences was received here, and it seemed quite clear that the proper time had arrived for taking the only step that remained for us by moving the whole community into the workshops.

In considering the details of this move it was suggested to me by Captain Maclagan that it would be a good plan to place the whole of the College Buildings under charge of the sepoys on the withdrawal

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of the Europeans from them, and as this seemed to me an excellent idea, orders were at once issued for giving effect to it. The Sepoys were informed that it had now become necessary to arrange for the defence of the station, and that relying on their conduct and loyalty I placed the cantonments and college under their charge and directed them to protect the same from all injury. Circular instructions were at the same time sent to all the inhabitants of the station directing them to move into the workshops in the course of the day taking with them such articles only as were indispensably necessary for them and their families.

Much excitement and alarm naturally prevailed but the movement into the shops was effected with wonderfully little confusion and by about 8 p.m. the whole European Community, with the exception of the officers attached to the Sappers who remained with their men, had been collected within the walls, and quarters moderately comfortable and perfectly safe were occupied by the women and children.

A strong sepoy guard under Lieutenant Fulford of the Engineers occupied the hall of the Thomason College. The men were obedient but their excitability was shown on the first rounds of the European night patrol, on hearing which approaching they suddenly flew to their arms, began loading, and seemed to think they were about to be attacked. Finding however that the patrol was friendly the excitement soon subsided and was not again shown.

The collection of stores to accompany the detachment under orders to join the Commander-in-Chief's camp having been completed, the company marched on the morning of the 18th to Secunderpore, it being intended that it should proceed *viâ* Saharunpore and Juggadrie. There were no difficulties made by the men about marching and they seemed all quite content to proceed to Delhi. The day passed quickly over, and the garrison of the workshops was organized and distributed at its different posts. Entrenchments in front of the gate-way were completed and a gun was mounted on the roof of the sheds near the gate, whereby the main street of the Native Town of Roorkee was completely commanded and could if necessary be swept with grape. The bridge also was secured by the same means. The carriages for the two other guns were completed so that by the 18th our force consisted of about 90 Europeans armed with carbines, and three guns. The men were of course wholly undisciplined but they were all in excellent heart and quite prepared, if need were, to defend themselves and their families as vigorously as Englishmen usually do.

The 18th was a day of intense anxiety and great risk. About noon a messenger arrived from Meerut in the Lines, and his arrival was followed by an outburst of weeping and wailing among the women of the regiment, and of excitement and agitation among

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the men, the effects of which were soon perceived by the European officers. About 3 p.m. Captain Drummond and Lieutenant Bingham reported to me that a rumour was current in the Lines of the whole corps at Meerut having been destroyed by grape, and that so great was the excitement in consequence that they conceived an outbreak possible at any moment. I stated that rumours of this kind were among the most likely means of agitation to be used by ill-disposed men among them, that I had myself a letter of the 16th from the Adjutant in which no allusion whatever was made to any catastrophe on that date, the letter was given to Captain Drummond and he carried it to the Lines with him and explained its contents to the men. His personal influence and that of Lieutenant Bingham were sufficient to prevent any disturbance at the moment but matters were so evidently near a crisis that I quietly warned the officers of the Garrison, and had all needful arrangements made to meet any sudden attack.

All was still however till about 10 p.m. when a sowar arrived from Secunderpore, and reported to me that the detachment there was in open mutiny, had insisted on returning to Roorkee to rejoin their comrades there. They were now about four or five miles distant. With this detachment there were two officers, Lieutenants Pemberton and Jeffreys of Engineers, one warrant officer and two European non-commissioned officers. The sowar informed me that he had seen the whole of the Europeans marching back with the men. The town of Roorkee was greatly agitated, many of the inhabitants were flying, and general alarm prevailed among the natives. I immediately sent men out on the road by which the detachment was approaching to watch its movements. About half a mile from Roorkee a side road diverges from the main line and, leading to the Guneshpore Bridge across the Ganges Canal, gives a direct communication with the cantonment without passing through the town of Roorkee. That the mutinous detachment should have left all its European officers unharmed and should be returning with them and the whole of the Public Stores under their charge seemed to indicate but little virulence of spirit and I concluded that probably no attempt would be made that night, at any rate, to disturb the peace of the place. It seemed farther probable that if the men were thus disposed they would avoid the workshops and take the direct road to their Lines. The videttes sent out to watch the detachment were instructed to forward instant intelligence of the line the company should take, and meanwhile the garrison was held in readiness for service according to circumstances.

About midnight information was brought to me from the advanced posts that the detachment had turned off from the main road and was marching direct to cantonments so that all immediate risk of a collision was postponed.

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On this I returned from the gate guard to the Esplanade of the workshops, and found there Captain Drummond, Lieutenant Bingham, and all the Europeans from cantonments. Shortly afterwards Lieutenant Pemberton with his party reported themselves to me, and somewhat later Lieutenant Jeffreys arrived in garrison. From these gentlemen I received statements of the progress of events outside the garrison during the night of the 18th.

Captain Drummond and Lieutenant Bingham slept in the quarter guard. Before midnight they were visited by the native officers and a party of the men who told them that they were certain of the destruction of the corps at Meerut, and that they were determined generally no longer to serve Government, but that many among them, and the party then present in particular, were anxious to save the European officers from harm, and had come to entreat them to leave the Lines at once, that all remonstrance was a waste of time and added greatly to the risks of mishap, as there were bad men among them who were then doing all in their power to provoke a collision in which the Europeans might be destroyed, but that they were prepared to conduct them in safety to the workshops. After some conversation it became quite evident to Captain Drummond and Lieutenant Bingham that their longer presence was merely provocative of evil, and they accordingly stated their readiness to leave. Collecting from the barracks all the Europeans there, the small party, consisting of 10 or 12 in all, was escorted by the native officers and men, who were observed to form a complete circle round them, beyond the college grounds and there they separated, the Sepoys returning to their Lines. Throughout, the bearing of the men was described as more than respectful, and no doubt was entertained by the officers that if they had been attacked the men with them would have protected them at the risk of their own lives. The party of Europeans as already mentioned reached the workshops in safety about midnight.

From Lieutenant Pemberton I learned the course of events with the detachment that had marched back from Secunderpore. The same messenger that had brought tidings of the collision at Meerut to Roorkee continued his progress to Secunderpore and communicated the intelligence to the detachment there. On receiving it the men seem to have taken their decision at once to return to Roorkee, having probably been requested to do so by their comrades there. The native officers communicated this decision to Lieutenant Pemberton, and, in reply to his remonstrances, only said that the detachment had determined to return and would obey no orders to the contrary. The men immediately commenced to get the store carts ready for the march. They maintained a perfectly inoffensive manner towards the Europeans and between 6 and 7 p.m. commenced their retrograde march. On reaching the lines about midnight the

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native officers requested Lieutenant Pemberton and the other Europeans to leave at once, which they accordingly did and joined us in the workshops, beyond the walls of which no European now remained.

I had a watch kept on the movements of the men in the Lines throughout the night, and just before daybreak one of the scouts brought me intelligence that a good deal of firing had been heard, that he thought some disturbance had broken out among the men themselves and that some were running away. I at once took measures for organizing as strong a party as could safely be spared from the Garrison, about 40 men, and attaching one gun to it, placed it under command of Captain Maclagan and sent it at daylight to clear the Lines and drive out any men who might be found there. On reaching the Lines Captain Maclagan found that the main body of the mutineers had fled before daylight towards the Ganges, that about 50, including several native officers, had remained in the Lines, and it was their determination to remain, and the collision this gave rise to, that had caused the confusion reported to me by the scout. The mutineers had seriously maltreated them, had fired into them, slightly wounded the old Subadar whose property to the value of Rs.2,000 they had plundered, tearing his gold necklace from his neck and his many medals from his breast. The other officers had only been less harshly used, the magazine had been broken open, some camp equipage destroyed, but the barracks were untouched. Strange to say the sentry at the quarter guard maintained his post throughout the collision, and was found upon it when the Garrison detachment occupied the Lines. The man was promoted to the rank of Havildar by the order of the Commander-in-Chief on the matter being reported to him.

Thus passed what I have ever considered as the real crisis of the mutiny for the station. Three hundred trained soldiers like the Sappers might have been very dangerous foes to a body of about 90 men hampered by the charge of upwards of a hundred helpless women and children. They would never have taken the workshops, I believe, but so much cover existed outside the walls for them that they would doubtless have caused many deplorable casualties. The station of Roorkee with all its public and private property outside the workshop walls was also temporarily at their mercy. Happily however they were considerably more afraid of us than we of them.

The men who were left informed me that they fully expected us to attack them on the morning of the 19th, and knowing we had three guns with abundance of " grape," their hearts failed them and they fled.

During the progress of the mutiny I had been in frequent communication with the residents of Saharunpore who were watching events here with deep and natural anxiety and was glad to be able

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to send intelligence early on the 19th that for the moment at least our position was perfectly secure.

The mutinous sepoys having been traced across the Ganges and found to be making apparently for Oude, there seemed little probability of their giving us any farther trouble, and attention could be given to the condition of the district around us which we had hitherto been compelled to neglect. Almost simultaneously with the arrival here of the news of the mutiny at Meerut, there arrived rumours of risings of the Goojurs and other marauding tribes. Their old instinct of plunder sprung up strong and active the moment it was conceived that our repressive influence had passed away, and several instances of petty attacks on Canal posts had been reported. On the 15th an attempt was made to sack the large town of Munglour, and constant rumours of designs against Roorkee were brought in. The object in all these attacks seemed to be merely plunder; they were in no way specially directed against Europeans or against the Government, but every large town having property or wealth was threatened. It was quite impracticable to take any active measures against the marauders while our small force was paralyzed by the presence of the mutinous Sapper sepoys. So soon however as they were disposed of, means were at once taken to re-establish order in the neighbourhood. The plan adopted, and followed throughout the period of the disturbances, was immediately to follow up any rumour of gatherings of marauders at particular places by a visit of part of the Garrison to such places. Collisions were very rare and, the plunderers having been made to feel the effects of such as took place as severely as possible, it was not long before we enjoyed comparative immunity from even the reports of their rumored descents. The system was commenced on the 19th the same day that relieved us from the presence of the Sappers, and scarcely a day passed during the ensuing month that some part of the district was not visited by our patrols. In some instances the towns-people themselves beat off the marauders, as on the 21st at Kunkull when eleven of the assailants were reported to have been killed, and on the 26th at Jowallapore, both considerable towns near Hurdwar. About the same time a strong body of Dacoits attacked the Ganges Canal Regulators at Myapore, with the evident object of possessing themselves of the wood and iron work to make weapons. They were very gallantly repulsed and a few of them killed by a party of Canal Beldars led by the Head Mistree of the section, Moollah by name, and were effectually prevented from doing any mischief. Had they succeeded in their attempt, we must have lost all command over the floods of the Ganges and it is scarcely possible to exaggerate the disastrous results that would have followed the unrestricted entrance of such vast volumes of water into the canal channel. I have always

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considered this feat of Moollah and his party to have been one of the most valuable that could have been performed, as it obviated the risk of the gravest damage being done to works which had cost Government very nearly a million sterling, and of deplorable consequences to life and private property besides.

On the 23rd, communication was opened with Saharunpore by a party from the Garrison riding over to that station. The road, usually covered with travellers of different classes, was found utterly deserted. On the 27th, a party of 8 or 10 officers and volunteers, with some armed Canal Beldars and a few mounted followers, accompanied me on a patrol to the neighborhood of Hurdwar. This was the first visit made by Europeans to those localities since the outbreak of the mutiny, and the reception given to the party by the inhabitants of Jowallapore, Kunkull, and Hurdwar, was to all outward appearance enthusiastic, and their professions of loyalty to the Government were earnest and profuse. I have never seen any reason since to question their perfect sincerity, and to the best of my knowledge and belief they have always behaved well. Our visit had an excellent effect in re-assuring the population, and satisfying them that the machinery of Government was not wholly out of gear among them.

It being considered very desirable to visit the southern portion of the district, and if possible to communicate with the isolated station of Mozuffernugger, where it was known that two or three officers were maintaining a most precarious position, a patrol left Roorkee on the 1st June, and proceeded down the Ganges Canal to Jowlee about 30 miles. For about 6 miles north of this point the villagers had been actively destructive, and had done considerable injury to the Canal works, chiefly however by carrying off all the iron and wood they could, doubtless as in other instances to provide themselves with weapons. Two villages had made themselves conspicuous in this plundering, and various articles of Government property having been found in them both were burned. The immediate effect was to lead to very large quantities of iron, that had been plundered by other villages from a fleet of canal boats, being brought back secretly during the night and deposited close to the Canal station house. The party proceeded from Jowlee to Mozuffernugger, and returned to Roorkee on the 4th, having made a circuit through the Saharunpore and Mozuffernugger Districts of about 70 miles without meeting the slightest obstruction, though being forced to observe that in the latter district the people gave them no welcome but showed so far as they dared that their feelings were hostile and bad.

Some anxiety was felt during the Eed, which was celebrated at this place on the 27th of May. A foolish or malignant report had been circulated in the town that when the Mahomedans had all assembled at prayer it was my intention to open the guns on them and destroy

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them. And a counter report was current among the European community that the Mahomedans meant to rise that day. The first report I took means to have summarily contradicted and personally assured some of the most influential Mahomedans in the place that, if they conducted themselves loyally and quietly as they had hitherto done, they need have no fear of any bad treatment from the Garrison ; while to satisfy them that we were able to protect ourselves against any rising, advantage was taken of the Queen's Birthday to show them the guns and Garrison in action by firing a royal salute and a *feu de joie*. The Eed passed over with more than usual quietude.

On the 6th of June, intelligence was received here of three Europeans, Mr. Sub-Conductor Stephens, his wife, and Corporal Bruce, attached to the Forest Department, having made their escape from the Patlee Dhoon, and being then in the hands of the Newab of Nujeebabad who was represented as treating them with much kindness and hospitality. As Bijnore was at the time believed to be occupied by the Civil authorities no immediate anxiety regarding the safety of the party was entertained. But on the 11th, the whole of the Europeans from Bijnore having arrived in Roorkee, the position of Mr. Stephens and his companions become very isolated and dangerous, and it was determined to make an effort to relieve them from it. This duty was undertaken by Captain A. C. Robertson, H.M. 8th Regiment, and Mr. H. B. Medlicott, professor of Geology, in the Thomason College. The 13th of June was fixed for their departure, and they were to have been escorted as far as Hurdwar by a party of Rohilkhund horse about 30 strong which had accompanied Messrs. Shakespeare and Palmer, C. S., from Bijnore. On the afternoon of 13th, however, Mr. Palmer reported to me that, on warning the men for the expedition, the native officer in command informed him that they refused to move without an advance of two months' pay ! As they had very recently before received pay and were only required to proceed to a place a single march off, Mr. Palmer who intended to accompany them very naturally concluded that an unreasonable demand of this kind indicated the prevalent spirit of mutiny among the men and sought my instructions. A number of ladies occupying my house at the time and the party being at dinner, I did not disturb them, but despatched a note to Lieutenant Baillie in command of the Artillery requesting him to get a gun ready for service, and to warn the Garrison day guard with such other Europeans as might be in the workshops, for duty. Allowing sufficient time for preparation, I then joined the detachment with Messrs. Shakespeare and Palmer, marched into the sowar's camp, disarmed them all and made them prisoners. No disturbance was created and the station generally was not aware of the event till it had passed, so all alarm was avoided. The matter

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was subsequently investigated, and some blame was attached by the Court-Martial to Mr. Palmer for prematurely reporting the men in mutiny. I thought however that Mr. Palmer had acted very properly and had quite sufficient grounds for his belief that the men were just trying how far they could go. It was no time to trifle with any symptoms of a mutinous spirit and I thought it right to order the whole of the men out of the station within 24 hours.

The defection of the expected escort was not allowed however to interfere with the expedition of Captain Robertson and Mr. Medlicott, who started the same evening for Hurdwar provided with letters for Mr. Stephens and a vernacular demand from myself addressed to the Nawab requiring him to deliver the Europeans to the officers sent to them.

The party crossed the Ganges on the afternoon of the 14th. Some armed Canal Beldars were posted at the Ghat on the left bank of the river, and a stronger body of the same occupied a point in the forest about 10 or 11 miles in advance where a bivouac was established on the night of the 14th till the moon rose. Then pushing forward with a personal escort of 12 Canal sowars, Captain Robertson and Mr. Medlicott reached the vicinity of Nujeebabad about 8 A.M. I had instructed them to halt about two miles from the town and to send forward a couple of sowars with the letters. This they did and the demand was instantly complied with by the Nawab. At 2 P.M. Mr. Stephens and his companions joined Captain Robertson on an elephant provided by the Nawab, and the whole party retraced their steps towards Roorkee which they safely reached on the 17th. Up to the last the Nawab had behaved with uniform kindness, and on their entire route the party had received all possible help from the villagers and such native officials as they came in contact with.

The whole expedition was admirably conducted by Captain Robertson and Mr. Medlicott. Their movements were so rapid that no time was left to the ill-affected party among the Nawab's advisers to raise any obstacles to the delivery of the prisoners and it was most satisfactory to have had them rescued in this way.

From very nearly the commencement of the disturbances it became necessary to rely on our own exertions for the collection of money from the district for the support of the Garrison and the maintenance of the works. I was very anxious that the latter should not be wholly stopped as bodies of men would then have been thrown loose on the country without any legitimate means of subsistence, and providing them with at least partial employment promised to be the best means of keeping them in order and also of giving to the people generally the impression that the machinery of Government was still maintained among them. This end was attained in all the public establishments at this place, none of which ever wholly suspended work. Captain Maclagan carried on the duties of the

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College, Captain Drummond those of the Canal, the workshops under Lieut. Baillie and Mr. J. Watson gave employment to considerable numbers of mechanics; and, though in all the amount of work done was necessarily contracted, it was still found to be sufficient for the object in view. No measures more rigorous than occasional visits to defaulting villages were found necessary for the collection of the Revenue, and the sums so collected with the occasional assistance of remittances from the Collector, Mr. Spankie, sufficed for all our wants.

The defences of the workshops had been steadily extended and increased as time and means permitted. A new entrenchment was made in front of the main Guard, and in it were mounted on Garrison carriages three old 18-pounders and an 8-inch mortar. The defect of flanking fire in the long walls of the shops was supplied by projecting musket-proof platforms. Loopholed walls were built where required, and palisades closed all open points. Shot and shells were cast for the guns and mortars, and for field purposes two brass and two iron mountain train guns with two 12-pounder howitzers were very successfully cast and bored in the workshops. The iron guns were I believe the first of the kind cast in India. A small body of sowars, 40 in number, were raised among the well-disposed villages, and was very useful in escort and patrol duties. The Beldars of the Ganges Canal having shown an excellent spirit throughout, a company 100 strong was formed of selected men from among them, drilled, and armed with carbines. About as many more were armed with spears and formed into cantonment and city guards for ordinary police purposes. The garrison guards were regularly organized and permanent posts allotted to each. Such interior arrangements as the comfort and health of the community required were made and maintained. Finding the most usual and pernicious causes of alarm among the garrison were unfounded reports of attacks from without and groundless apprehensions of treachery within, it appeared to me that if information as accurate as circumstances would permit were circulated to all a sedative effect would be produced. It was at first intended to do this merely in manuscript but as means and labor were both available from the College Press, and at the time unemployed, they were made use of. Out of these circumstances arose the little paper called "The Roorkee Garrison Gazette" designed solely for the limited object above referred to and of which only 60 copies were printed. The general management was placed in Captain Maclagan's hands, but the proofs were invariably read, and the local articles almost as invariably written, by myself so long as I remained at Roorkee. I was made aware of but one indiscretion in the management, the giving of certain information relative to the actual strength of the force before Delhi which should not have appeared, otherwise

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I believe the information circulated was not only inoffensive but useful and certainly the local object contemplated was well served by it, as when people knew regularly what was going on about them we were singularly free from every thing like panics or extravagant alarms. I have thought it right to allude briefly to this matter as I had of course no authority for the act of establishing a paper of the kind, and if there was any impropriety in it the responsibility must be exclusively mine.

Between June and October but little occurred to vary the ordinary tenor of garrison life. On the 22nd June a party of about 200 Goojurs gathered at Munglour to plunder that town. Captain Robertson, H.M.'s 8th, and Lieutenant Pemberton of Engineers were sent with a small detachment of Sappers to disperse them. The marauders began to retire the moment they heard of the approach of the detachment, but Captain Robertson and Lieutenant Pemberton pushing on with only four Canal sowars as escort, dashed in among them, slew three, and captured eight. The Goojurs were rudely armed with old matchlocks, spears and the like, but the whole body fled in confusion then as they ever did before even the smallest of our parties. The eight prisoners were tried and hanged. On the 26th I received orders to proceed to Delhi, and left on the 27th with a large convoy of stores for the Engineer park, and 600 Beldars to serve as Pioneers. The command of the Garrison devolved on the next senior Officer, Captain H. E. Read, 50th Native Infantry.

No active movements of any importance were made until the 14th July, when a party of officers and volunteers with a detachment of Sappers, a gun, and some Sikh Horse proceeded under command of Captain Maclagan of Engineers to Futooah, a village in an island between the Bangunga and Ganges, where a large body of marauding Binjarris and others had concentrated, and from whence they issued to plunder the villages of the Ganges, Khadir carrying off cattle and grain, and driving the inhabitants away from their homes. The detachment was entirely successful, dispersed the plunderers, recovering large stores of grain, and about 300 head of cattle, with a number of prisoners, the ringleaders among whom were executed.

The party returned on the 18th, and next day another detachment under Captain Read with two guns proceeded to the relief of the town of Deobund, which had been kept for some time previous in a state of siege by hordes of Goojurs and was in great danger. A detachment of the Nusseeree Battalion from Saharunpore reinforced the Roorkee party and a combined attack ended in the utter dispersion of the plunderers. With this affair terminated the necessity for active operations on the eastern side of the District. The country continued perfectly quiet, revenue was paid in freely and, on my return to Roorkee on the 29th September, I saw no necessity for continuing longer the organization of the Garrison. It was accordingly broken up on the 1st October, its members resumed their

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ordinary duties and the station was fully re-occupied. Precautions however were taken to keep all defensive arrangements in efficient order in case of farther disturbances. The Europeans retained their arms. A month's supply of provisions was kept within the workshops and the ordnance was carefully kept in condition for immediate service. It was thus possible at any moment if need should be to resume our defensive position.

The conduct of the whole garrison was throughout self-reliant, cool, resolute, and most exemplary. Officers and men were alike ever ready for active work; and, weak though their numbers were, the maintenance of the peace throughout a large section of this district, the salvation of public property considerably above a Million Sterling in value, of private property of material amount both in the station itself and in the Native towns around it, and the support of the authority of the Government, were among the results of their activity, courage, and devotion.

In compliance with the instructions contained in para. 7 of Circular No. 212, I have the pleasure to submit the names of the following officers for active and meritorious service during the period of disturbances at this place:—

Captain H. E. Read; 50th Native Infantry.
Captain R. Maclagan; Engineers.
Captain H. Drummond; Engineers.
The late Captain F. Spring; H.M.'s 24th Regiment.
*Captain A. C. Robertson; H.M.'s 8th Regiment.
Lieutenant G. Baillie; Artillery.
Lieutenant E. L. Earle; Artillery.
The late Lieutenant T. E. Dickens; Artillery.
Lieutenant R. C. B. Pemberton; Engineers.
Lieutenant H. W. Jeffreys; Engineers.
Lieutenant R. F. Angelo; 41st Native Infantry.
Lieutenant H. Bimgham; Head Master, Thomason College.
Mr. H. B. Medlicott, Professor of Geology, ,,
Mr. H. Martin; Assistant Superintendent-General of Irrigation, N.W.P.
Mr. Conductor J. Finn; Superintendent of Navigation.
Mr. James Watson; Practical Engineer, Roorkee Workshop.

I may also be allowed to express here in a few words my grateful sense of the constant, cordial and most effective assistance given to the community of this station by the Magistrate and Collector of the District, Mr. Robert Spankie, during the whole period of the Mutinies.

I have, etc.,

R. BAIRD SMITH.

* Capt. Robertson was at the time Deputy Superintendent of the Ganges Canal Northern Division.

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Nominal Roll of Officers of all Grades attached to the Irrigation Department, North Western Provinces, the Thomason College of Civil Engineering, and the Forest Agency in May, 1857, with Notices of their Services during the Mutinies.

Divisions.	Names of Officers.	Appointments.	Head-Quarter Stations.	Notes of Services.
I. Irrigation Department N.W.P. (General).	Lieutenant-Colonel R. Baird Smith.	Superintendent General of Irrigation, N.W.P., and Visitor, Thomason College.	Roorkee.	Commanded at Roorkee from 12th May to 27th June, 1857; proceeded to Delhi as Chief Engineer of the Force there; returned to Roorkee 30th September, 1857, and placed in command of the Troops in the Saharunpore and Mozuffernugger Districts.
Do.	Mr. H. Martin.	Assistant do. do.	Roorkee.	Mounted Patrol, employed on District service, proceeded to Delhi 27th June, and served there throughout the siege.
Ganges Canal, Northern Division.	Capt. H. Drummond.	Superintendent.	Roorkee.	Commanded Detachment of Sappers and Miners at Roorkee between 13th and 18th May, 1857; brought to notice of His Excellency the Commander-in-Chief for courage and conduct during the mutiny of the detachment; constantly employed on Field Service in Saharunpore District between May and September; maintained complete order in his Division. Served as Commanding Field Engineer with General Jone's Column in Rohilkhund.
Do.	Captain A. C. Robertson, H.M.'s 8th Regt.	Deputy Superintendent.	Roorkee.	Commanded Reserve Guard till 27th June, 1857, Constantly employed on Field service in Saharunpore District; conducted successful expedition in June; for rescue of 3 Europeans from Nujeebabad; attacked and dispersed marauders at Munglour; proceeded to Delhi to rejoin his Regiment 27th June and actively employed there, and at Lucknow.
	Mr. W. Phillips.	Supervisor.	Roorkee.	Mounted Patrol; field service in the District.

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DIVISIONS.	NAMES OF OFFICERS.	APPOINTMENTS.	HEAD-QUARTER STATIONS.	NOTES OF SERVICES.
Navigation and Material Department.	Mr. Thomas Martin.	Asst. Supervisor.	Roorkee.	Main Guard.
	Mr. James Finn.	Superintendent.	Do.	Commanded west guard; in charge of Commissariat and Intelligence Departments; rendered services of the highest merit.
	Sergeant Ogle.	Overseer.	Cawnpore.	Killed there with his family.
Workshops.	Lieut. G. Baillie, Artillery.	Officiating Superintendent.	Roorkee.	Commanded Artillery; equipped the Guns for service. Superintended all interior work in the workshops, constantly employed in district field service, proceeded to Delhi 18th June, served there and in the Districts of Saharunpore and Mozuffernugger up to present date.
	Mr. J. Watson.	Do.	Roorkee.	West Guard. Officiating Superintendent after Lieutenant Baillie's departure to Delhi; Superintended casting of Guns, shot, and shell; equipped 3 18-Pounders, 2 8 Mortars and 4 Mountain Train Guns for service; was indefatigable in his exertions.
	Mr. J. McArthur.	Assistant Supervisor.	Roorkee.	Attached to Artillery and Store keeper.
	Sergeant Wilson.	Overseer.	Roorkee.	Gate Guard.
	Sergeant Ainsworth.	Overseer.	Roorkee.	Gate Guard.
	Trooper Cummings.	Assistant Overseer.	Roorkee.	Main Guard.
Upper and Lower Central Divisions.	Mr. James Parker.	Superintendent.	Bolundshahur.	Employed constantly on active service in the Meerut and Bolundshahur Districts, and engaged repeatedly with marauders; restored order in his Divisions with much energy, and throughout did excellent service.

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Divisions.	Names of Officers.	Appointments.	Head-Quarter Stations.	Notes of Services.
Upper and Lower Central Divisions.	Mr. C. Anderson.	Depty. Superintendent.	Futtehgurh Branch.	In camp alone when the mutiny broke out, and escaped to Meerut with great risk of life; actively employed in maintaining order; proceeded to Delhi in August, and served there as Local Ensign with the Punjab Sappers; wounded.
	Mr. H. Nuthall.	Depty. Superintendent.	Camp.	Actively employed in Meerut District; proceeded to Delhi in August, and served there as Local Ensign with the Punjab Sappers; continued service in the Doab, at Lucknow, and in Rohilkhund to present date.
	Mr. W. B. Macrone.	Depty. Superintendent.	Alleegurh.	Actively employed in district service.
	Munnoo Lall.	Assistant Superintendent and Depty. Magistrate.	Bolundshahur.	Actively loyal and energetic throughout the whole period of the mutinies; recovered large quantities of public property, and materially aided in restoring order and confidence in his charge.
Cawnpore Terml. Division.	Lieutenant G. Price.	Superintendent.	Cawnpore.	Proceeded to Calcutta, 4th June.
	Lieutenant F. Angelo.	Officiating Superintendent.	Do.	Killed in Entrenchment.
	Captain Tonnochy.	Depty. Superintendent.	Mynpooree.	On Separate duty.
	Petumber Sing.	Asst. Superintendent and Deputy Magistrate.	Secundra Rao.	Actively loyal throughout the mutinies.
	Madhoo Ram.	Do. do.	Cawnpore.	
	Sergeant Swan.	Asst. Overseer.	Camp.	Escaped to Agra, and did duty in the Fort there.
	Sergeant Burton.	Do.	Do.	Killed, or died naturally under circumstances unknown.
	Sergeant Fullerton.	Do.	Do.	Killed or died naturally under circumstances unknown.

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DIVISIONS.	NAMES OF OFFICERS.	APPOINTMENTS.	HEAD-QUARTER STATIONS.	NOTES OF SERVICES.
Etawah Terml. Division.	Captain F. Whiting.	Superintendent.	Mynpooree.	Escaped towards Agra. Killed on or about the 27th June, 1857.
	Lieutenant O. Span.	Depty. Superintendent.	Camp.	Escaped to Agra, Died in the Fort there.
	Sergeant R. Kelly.	Overseer.	Do.	Killed under circumstances unknown.
	Sergeant Mitchell.	Do.	Do.	Escaped to Agra, and did duty in the Fort there.
	Sergeant Scott.	Do.	Do.	Do. do. do.
	Mudsooden.	Assistant Supervisor.	Do.	Actively loyal throughout the mutinies.
Eastern Jumna Canal.	Lieutenant H. A. Brownlow.	Superintendent.	Saharunpore.	Actively employed in maintaining order at Saharunpore; proceeded to Delhi, and served throughout the operations; dangerously wounded; served in Rohilkhund with General Jone's Force; restored order in his division with energy and tact.
	Lieutenant R. Home.	Depty. Superintendent.	Do.	Employed in District service.
	Mr. W. Willcock.	Do.	Surrowlee.	In hands of Goojurs with his wife and family for some time; treated by them with much kindness, and brought to Saharunpore; actively employed in District service; proceeded to Delhi and served there as Adjutant of Pioneers.
	Sergeant Brown.	Assistant Overseer.	Camp.	Also in hands of Goojurs. Employed in district service.
Western Jumna Canals.	Lieutenant Stewart.	Superintendent.	Delhi.	In Camp at time of Mutiny at Delhi; escaped to Kurnal; joined Delhi Field Forces and served throughout the siege. Active and energetic in the restoration of order in his Division.
	Lieutenant Thomason.	Depty. Superintendent.	Do.	Escaped from Delhi on 11th May; and, after much suffering, reached Kurnal; served at Delhi throughout the siege.

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Divisions.	Names of Officers.	Appointments.	Head-Quarter Stations.	Notes of Services.
Western Jumna Canals.	Mr. H. Rigby.	Depty. Superintendent.	Camp.	Served at Delhi as Local Ensign with Punjab Sappers; died of fever.
	Mr. Fitzpatrick.	Assistant Supervisor.	Hansee.	Killed there.
	Sergeant Duncan.	Do.	Dadoopore.	Maintained his post throughout the whole period of the mutinies, and showed great gallantry and judgment in doing so.
	Sergeant J. Martin.	Assistant Overseer.	Do.	Aided Sergeant Duncan and did excellent service.
	Sergeant Corcoran.	Do.	Kurnal.	Served with Artillery at Delhi during the siege; wounded.
	Sergeant Dennis.	Do.	Delhi.	Killed there on 11th May.
Deyra Doon Canals.	Lieutenant E. Walker.	Superintendent.	Deyrah.	Left Deyrah 15th May with Simoor Battalion; District service in Bolundshuhar district; present in the actions on the Hindon; joined at Delhi, and was severely wounded there; died of Cholera in July, 1857.
	Mr. R. Forrest.	Depty. Superintendent.	Do.	In charge of works; occasional district service
Rohilkhund Canals.	Captain Maxwell.	Superintendent.	Barrielly.	Employed on active service at Nynee Tall; repeatedly engaged with the mutineers from Barrielly.
	Mr. Aspinal.	Assistant Superintendent.	Do.	Killed with his family at Barrielly.
	Mr. Bremner.	Do.	Pilibheet.	Prisoner from May to February when he escaped to Nynee Tall.
Bundelkhund Works.	Lieutenant J. Powys.	Superintendent.	Nowgong.	Killed with his family at Jhansee.
	Sergeant Kirchhoff.	Overseer.	Mahoba.	Escaped after great danger and suffering to Cawnpore with his wife; died there of Cholera.
Agra and Delhi District Works.	Mr. E. Battie.	Superintendent.	Agra.	Did duty in Fort and district.

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DIVISIONS.	NAMES OF OFFICERS.	APPOINTMENTS.	HEAD-QUARTER STATIONS.	NOTES OF SERVICES.
II. Thomason College.	Captain R. Maclagan.	Principal.	Roorkee.	Staff Officer of the Garrison; constantly employed in field service in the District; commanded successful detachment against a strong body of marauders at Futooah, and aided in all measures of internal defence at the station.
	Lieutenant G. T. Chesney.	Assistant Principal.	Roorkee.	At Umballah when the mutiny broke out; proceeded with Commander-in-Chief's Force to Delhi, and served there as Brigade Major of Engineers throughout the whole of the operations. Severely wounded.
	Lieutenant E. L. Earle.	Professor of Surveying.	Roorkee.	Commanded Gate Guard and attached to Artillery. Employed in District service; proceeded to Delhi 19th June, and served throughout the siege.
	Mr. H. B. Medlicott.	Professor of Geology.	Roorkee.	Mounted Patrol, constantly employed in field service in the District; accompanied Captain Robertson to Nujeebabad for rescue of Europeans there; engaged with insurgents at Deobund.
	Lieutenant H. Bingham.	Head Master.	Roorkee.	Acting Adjutant of Detachment Sappers and Miners; brought to notice of His Excellency the Commander-in-Chief for courage and conduct during the mutiny; proceeded to Delhi and served throughout the operations there as Commandant of Pioneers; also in the Doab, at Lucknow, and in Rohilkhund.
	Captain F. Spring, H.M. 24th Regiment.	Senior Department.	Roorkee.	Commanded Main guard; of the greatest assistance in organizing the Garrison, and distinguished by his zeal and professional intelligence on all occasions. Proceeded to join his Regiment 29th June, 1857, and killed at Jhelam by the mutineers of the 14th Native Infantry.

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Divisions.	Names of Officers.	Appointments.	Head-Quarter Stations.	Notes of Services.
II. Thomason College.	Lieutenant R. F. Angelo.	Senior Department.	Roorkee.	Commanded East guard; employed in district service.
	Mr. W. Scotland.	Drawing Master.	Roorkee.	Gate Guard; service in the district.
	Sergt. Gilchrist.	Assistant Master.	Roorkee.	Acting Sergeant-Major; rendered most useful service.
				The Students of all Departments of the College were embodied for Military service.
III. Forest Agency.	Captain H. E. Read.	Superintendent.	Roorkee.	Commanded at Roorkee from 27th June; constantly employed in the districts; commanded successful expedition for the relief of Deobund, and defeated a large body of insurgents there. Most active and energetic throughout the whole period when service was required.
	Mr. Sub-Conductor P. Stephens.	Forest Overseer.	Patter Dhoon.	Prisoner at Nujeebabad; rescued with his wife 17th June; commanded Garrison Artillery, after all the Artillery officers left for Delhi.
	Sergeant H. Bruce.	In charge of Saw Mills.	Do.	Prisoner at Nujeebabad; rescued as above; attached to Garrison; employed in District; in charge of Engineers Park with General Jone's Force in Rohilkhund.

R. Baird Smith, *Lieutenant-Colonel,*
Superintendent, General Irrigation, N.W.P.

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TRANSCRIPT.

ON AN INDIAN CANAL.

By MAJOR-GENERAL G. K. SCOTT-MONCRIEFF, C.B., C.I.E.

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(*Continued*).

II.

THE province of India above all others which, from its natural configuration, is especially adapted to irrigation works on a large scale, is the Punjab. The work there of late years has been carried out under difficulties unknown to the engineers of the earlier days in the Ganges valley and elsewhere, because of the barren and uninhabited nature of the country; but it is an even greater boon to the people there, and it is more than in any other place remunerative to the State. The rainfall in the country watered by the Ganges and Jumna Canals is about 30 in. or more on an average in the year, whereas in the Central Punjab it is about 10 to 16 in., and in some years falls as low as 4 or 5 in. The State is the owner of huge tracts of waste land which can be cultivated if only water can be brought to it, and the whole province is divided into clearly defined sections bounded by the Indus and its five great tributaries. So we have in this province plenty of culturable land, but needing water for cultivation, plenty of water rolling down the great rivers, and a strong and hardy race of agricultural people willing to take up the work. The problem has been to bring them all together. Curiously enough, nearly the entire province is a great plain of alluvial and excellent soil overlying a water-bearing stratum. If a well be sunk anywhere on this plain, it will tap the water-level at no very great depth sooner or later. Indeed, if one travels by rail from the mouth of the Indus at Karachi to Lahore, and thence by Umballa and Allahabad to Calcutta at the mouth of the Ganges, one passes over this great alluvial plain from end to end. The railway does not pass through a single tunnel the whole way (about 2,000 miles), and, except for a short distance in Bengal, does not even pass through a cutting deep enough to obstruct the view from the railway carriage. If the traveller is journeying in the months of June or July, he will not desire to see the view, and there will be little for him to see but a shimmering plain with a blinding glare. His one desire will be to darken his carriage as much as possible, and provide himself with iced drinks and refreshing literature. But if the journey is taken in April, there will be a sea of ripe golden wheat traversed for hundreds of miles, or in September the still more picturesque crops

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of maize, millet, or sugar-cane gladden the eye. These are largely due to the influence of irrigation, either from the great canals or from village wells.

These last are a most important feature in the Punjab. There are some 300,000 of them. Where the rainfall is from 15 to 20 in., and in places where the water-level is not more than 40 ft. below the surface, these wells are found in every village, and the water from them is raised by Persian wheels, whose not unpleasant drone is a familiar sound to every one who has been in North India. In the hot dry months of April and May the wheels are worked day and night, the water brought up in the tiny buckets falling into wooden shoots, and thence led through small channels to the thirsty ground. This goes on till the anxiously expected rain gives the tired bullocks or buffaloes a rest, and the farmer can wait till his harvest comes.

But as the ground rises gently away from the valleys of the rivers, the level of the water in the wells gets farther and farther from the surface, cultivation then ceases, and what is called the "Bar," or waste land, begins. The soil is smooth and shining, bare of grass, and dotted all over with shrubs of three different kinds, two of which are rough thorn bushes, while the third (called various names, *jàl* and *pilu* and *van*) resembles in leaf the mistletoe, and has a white wood, which, as well as the leaves, has a peculiarly disagreeable odour. These shrubs, like the gazelle and the camel, can live with impunity in long droughts. The people who inhabit these tracts are pastoral, owning large herds of cattle, buffaloes, and camels. The last-mentioned animal can live upon, and seems to enjoy, the thorn bushes and the malodorous *jàl;* but the cattle must have grass, and therefore the owners move about from place to place, like the patriarchs of old, according to the state of the country. The human inhabitants are a fine sturdy race, living almost entirely on milk and curds, with very little clothing either in summer or winter. They are men of simple tastes and habits. They know little of civilization and not much of agriculture; but if you should chance to lose any of your baggage-camels, or lose your way (which is a very possible contingency in such a trackless country), you will find that these peasants have a knowledge which you do not possess and which is exceedingly useful. The other denizens of the Bar region are snakes and lizards, kites and vultures, occasionally an antelope or gazelle, a few partridges and blue rock-pigeons.

There have been for many years, in the neighbourhood of the great rivers, canals dug in such a way as to fill when the rivers are in flood—*i.e.*, during the summer months, when the snows of the mountains are melting, but empty during the cold weather, when the rivers are low. These inundation canals, as they are called, are very useful adjuncts to the prosperity of the country, and they pay the State a very respectable return on the capital invested in their construction. They have, however, many drawbacks. The rivers constantly change their course, so that the position which has been suitable as a head for the canal one year may in the following year be far away from the water; while, on the contrary, the river may take a turn the other way and sweep away any small works devised to regulate the flow at a canal head. Then

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the water may fail, by the river falling, just at the very time the farmer wants it most; or it may come with a mighty rush at a time when he does *not* want it, and it cannot be turned away. The inundation canal, therefore, is far from being an ideal one.

It requires no expert knowledge to see that there must be some means of utilizing the water when the river is low, and of getting rid of superfluous waters when rain has fallen or the need for irrigation has ceased. A canal devised to supply these wants is called a " perennial " canal.

The first requirement is met by a weir across the main stream. The construction of a weir is a task for a Titan, and yet when it is all accomplished there is little to indicate above the surface the mighty work that has been carried to completion. People sometimes visit the head works of a canal expecting to see something that will attract the eye like the Forth Bridge, or the great Vyrnwy Dam that has created in Wales an artificial lake to supply Liverpool with water. They are disappointed that, having come out to the wilderness to see a work that has taken several years to build, there is only a very low bank of masonry over which the water is placidly flowing, or furiously tossing, according to the season. But to the man who has built it, a weir is almost part of himself, a child of his brain that has cost much travail and care, a mighty proof of mind and a sign of victory. Day after day, month after month, ay, year after year, it has been uppermost in his thoughts. It has involved a warfare against a crafty and vigilant foe, a grappling with a wild and untamed monster, who has not yielded without inflicting at times heart-breaking loss, and who has developed unexpected powers of resistance at times when all precedent pointed to capitulation. To supply the food of the assailant, too, what gigantic efforts have been necessary. One, two, even three, train loads of stone every day are swallowed up in this conflict, and other materials in like proportion. The army of invasion has to be organized, managed, directed by day and night, in cold and heat. The work has to be subjected to the severest tests while it is yet fresh from the masons' trowels, and, while the materials must always be of the best, reliance must be placed rather on design than on workmanship, on strategy rather than tactics.

A weir is, in short, a broad and deep bar of stone and concrete across the shifting bed of a river. There are miles of training works which radiate from the ends and prevent the river outflanking it altogether, and the foundations are laid so deep and so continuously that the water cannot undermine it. The river is, in fact, compelled to obey man's behests. The water must either pass over the weir or into the canal, the head of which is situated on one bank just above the weir. The river, too, must excavate a deep pool just at the canal head, so that the entrance to the canal may never be choked by silt. This is done by means of under sluices through the weir at the end close to the canal head, arranged so that the water is, so to speak, attracted to pass through them when it can escape nowhere else, and thus its current scours out a pool just at the place where such is needed.

When the country is dry and the river low, the weir prevents any water from passing over it at all, if such be the will of the canal engineers. Shutters along the top of the weir are raised, the under

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sluices are closed, the entire volume of the stream pours through the arched gates of the canal into the great artificial bed prepared for it. In the Chenab and Sirhind Canals nearly every cold weather the whole current of the rivers, Chenab and Sutlej, is thus utilized. But when rain has fallen, and when the farmer does not need the water, the shutters along the weir are dropped, the gates at the canal head are closed, and the river careers in foaming torrent over the weir down its ancient channel.

Superfluous waters in a canal are disposed of by "escapes"—*i.e.*, sluice-gates opening into some natural or artificial water course down which the water can be allowed to flow away.

In the case of the older canals, the water was brought to the villages which existed prior to the canal. But in the case of the Bar reclamations there were no villages worth mentioning, and so these had to be brought to the water. In other words, new villages were planned to be peopled by colonists from congested districts, and built in positions most favourable for agriculture.

The basis of the whole scheme was a square of about 27 acres in area, a suitable size for a peasant farmer. On paper the whole thing was delightfully simple. You have your tract of waste land, say, 100 miles long by about 30 broad, all of which has been proved, from the preliminary surveys, to be capable of irrigation, and which has formed the subject of many reports, and finally of the Secretary of State's sanction. You draw a straight line down the middle as a sort of backbone, and you draw other lines at right angles to this and parallel to it, until the whole area is divided up into a vast number of 27-acre squares.

Now go out and mark it on the ground. It is not quite so easy. To lay out an *absolutely* straight line on the ground for 100 miles may be possible, but to lay out hundreds of squares depending on this centre line with anything like scientific accuracy is hopeless. As one gets farther and farther away from the backbone, the squares become more and more lozenge-shaped, diamond-shaped, and otherwise distorted. However, the Punjabi peasant is not very particular, and the actual area of the plot is not far out one way or the other. Every corner peg of each square has to be accurately levelled,—*i.e.*, to have its level accurately recorded to the hundredth part of a foot,—so that long before the detailed design for the works even can begin, a host of workers, European and Native, must be busy each cold season, from dawn till dark, living in tents, and moving from place to place as the work develops.

By the month of April tents become unbearable, and the shimmering haze on the ground makes accurate levelling impossible. Looking through the telescope of your instrument, you will see the levelling staff, a very rigid piece of wood and brass, so distorted by the haze that it is apparently wriggling like a snake, or rather performing a feat no snake ever succeeded in accomplishing—viz., standing on its tail and dancing.

Now the accuracy of levels is a matter of vital importance where the flow of water in open channels is concerned. It is important, of course, in other branches of engineering, such as railway work, but if you do chance to make a slight mistake there (and I have heard of a case where

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a mistake of 10 ft. was not discovered till two ends of a cutting were found to meet at a difference of that level), it is possible to make the gradient differ a little one way or other. But with water this is impossible; hence when the weather makes the levelling staves wriggle, it is time to stop work for the season and begin the paper work.

A long and arduous task is this: first the planning of the distribution system,—whether the gigantic leaf will be like that of the oak, with a central main channel and a series of distributaries branching right and left; or whether it will resemble the plane or the vine, with a bifurcation at the end of the stalk and a series of branches proceeding thence, each with its own system. In any case, these have to be settled according to the conditions of the ground, not forgetting, too, that where there is irrigation there must also be drainage, or the land will be waterlogged and the inhabitants unhealthy.

Then comes the settling of village sites and the channels leading thereto. The design of the falls, the regulators, the escapes, the bridges, the diversion of roads, the positions of inspection-houses, and probably the planning, or at least the selection, of the site for a new town to act as a headquarters of the new district, have all to be taken up, designed, and estimated—a stupendous task, and one which will be most carefully scrutinized by superior authority in its most minute details.

For it has always been a tradition in this department that no detail is too insignificant to be slurred over. Financial control is not understood merely to mean the authority to spend money on a given work in any way you please, and then to examine the accounts. Examination certainly does take place with scrupulous exactness, but it is not there that economy comes in. It is recognized that economy must begin with the early stages of the work—scrupulous care in connection with the scientific planning, and the materials specified. This does not mean that these are inferior—on the contrary, no better workmanship is to be found in the country; but it must be so controlled in every detail that no useless expense is allowed anywhere. This means often long delay before a work is actually begun, but it is time well spent.

Here the reader will perhaps pardon me if I digress for a moment to give a personal testimony. I served for about three years, at various periods, in a varied career now of some 34 years, in the Irrigation Department, and was three times summoned away by telegram to go on active service from a canal. I found the experience I had gained there of infinite value to me in war, in the practice gained in organizing masses of men and planning for supplies of all sorts. But I learned also, in a way that has proved of incalculable value, the lesson of practical economy on a large scale. I have served in every other branch of the Public Works Department in India, have carried out works under Government in various other parts of the world, and have a very fair knowledge of what is done in civil life at home on railways, harbour works, and water-supply schemes, but I have never come across in any place any large works so thoroughly and efficiently managed as those of the Punjab Irrigation Branch.

There are two results of this. One is, that one never hears of a large contractor making a fortune out of the canal works, as one does in

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connection with other engineering schemes; the other is that partly due to this economy, and partly to the natural configuration of the Punjab, the canals pay an enormous profit to the State.

As regards the last point a few facts may be quoted. The immortal Mr. Gradgrind, we may remember, was above all things desirous to obtain facts. Well, there is a report annually published by the Punjab Government, called the Administration Report of the Irrigation Branch, full of the hardest facts that the mind of man could ever be called to digest, and purchasable at a cheap price from any Government publisher. It contains the exact area of every crop grown on watered land. The names of some of these crops will be new and strange facts to Mr. Gradgrind, but this is a matter of detail. The lengths of all the channels, main and subsidiary, the cost of every canal, the maximum amount of water which it is capable of discharging, and the maximum that it did discharge at any second of the year, are all recorded in a manner so interwoven that one is reminded of the accounts of a Mess, where it is said that in order to arrive at a balance sheet the secretary multiplied the butter by the potatoes, and divided the product by the honorary members.

From this mass of facts we learn that the Chenab Canal, the largest of the Punjab canals, so far, but still only one among several, has cost Rs.28,227,748, that the gross receipts in 1906 were Rs.8,762,061, the working expenses Rs.1,961,473, leaving a net revenue of Rs.6,800,588, or a percentage on capital outlay of 24·09. The interest charges on the capital, however, amount to Rs.1,093,926, which, deducted from the net revenue, leaves a surplus of Rs.5,706,662, or a net percentage of 20·22. The area irrigated is approximately two million acres, and the value of the crops raised in *one year* (from land which a few years ago was entirely waste) is given at Rs.38,565,915,—*considerably in excess of the total capital cost.*

The canal discharges at a maximum 10,730 cubic ft. a second. Its main line is 40 miles long, its branches 387 miles, and its distributary channels 2,308 miles. This takes no account of minor village channels.

To grasp these huge figures, let us take for comparison the water supply of London with its seven million inhabitants. For municipal, trade, and domestic purposes 30 gallons per head per diem of the population are considered necessary, or 210 million gallons in 24 hours, for the entire city and suburbs. Now if all this quantity were obtained, not, as it is now, from several different sources, but in one large stream, it would be equal to a discharge of 400 cubic ft. a second. Hence the Chenab Canal is designed to discharge water enough to supply 26 cities as large as London, with a population of 182 millions, or the entire domestic, industrial, and municipal needs of the British Isles, France, Germany, and Austria combined!

This is the largest of the great perennial canals, but there are four others (the Bari Doab, the Western Jumna, the Sirhind, and the Jhelum) which discharge each more than 4,000 cubic ft. per second. Setting aside the Western Jumna Canal, which is the reconstruction of an old native work, one may say that in this province of India the engineers of the Victorian era have devised and carried out a system

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of water distribution more than is needed for all requirements in respect of water supply by the entire population of Europe.

Then as regards revenue, the direct returns only are put to the credit of the canals; but this means only the enhanced land revenue paid by the people over and above the ordinary rent paid for unirrigated land. Even in lands watered by wells, where the farmer himself supplies the labour for raising the water, a higher land revenue is paid than would be paid for land which had to depend on rainfall only for its moisture. It is therefore in accordance with the fundamental principle of land assessment—viz., that a percentage of the value of the crop is paid to the State—that canal-watered land should pay the highest revenue. The credit to the canal department is useful enough, 20 per cent. being considered by anybody a very satisfactory return, but after all it only represents a part of the benefit conferred by irrigation on the people. The crops, which in one year exceed in value the entire capital outlay, would never have grown at all on the Bar land but for canal water; and the millions of acres now under cultivation are no longer populated by snakes and lizards, but by a thriving class of vigorous peasants, in whose welfare is the real strength of the nation.

It is not the least part of the skill with which these works have been devised, that from first to last they are designed to be carried out by native labour and materials. It is safe to say that of the capital expenditure at least 90 per cent. has found its way into the pockets of the people of the country. The excavation of the hundreds of miles of irrigation channels, large and small, has been effected by swarms of humble labourers, with their rude mattocks and baskets. Entire families are employed, the men doing the digging, the women carrying the stuff to the spoil heap, the children, according to their age and strength, carrying out some part of the work, either helping to lift the baskets or break up the clods in the spoil. So remunerative, indeed, is this simple labour that one tribe, who were originally employed on the Ganges Canal works some sixty years ago, have now abandoned agriculture, and go about the country from one canal work under construction to another. These people, who are locally called Odes, are skilful navvies and earn excellent wages, but they have become arrogant and troublesome, presuming on their superior skill. Hence they have been somewhat humorously described as "Odi profanum vulgus."

No doubt a modern digging machine, with its huge steel jaws taking at one bite as much earth as a whole family of Odes would do in a day, would carry out the work as cheaply, and probably more expeditiously, than the swarm of human ants above described. But such an application of modern machinery is unnecessary, because there are many other works on a canal to be constructed as well as the actual digging, and these always take most time. Besides, the rulers of the land are as much opposed to free trade in labour as any British workman can be, and the capital cost and the working expenses of such labour-saving machinery would not benefit the people of the land. Their comfort and advantage are studied everywhere, as indeed is only right. The bridges, falls, regulators, and other masonry works which occur so frequently over the canal system, are all designed so as to be made of materials

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either quarried or manufactured by native labour and built by native artisans.

In this, irrigation works contrast favourably with other public works. In railways, for instance, much of the capital expenditure goes to rolling stock, permanent-way materials, and signalling instruments, all of which are of European manufacture. The working expenses on railways involve the employment of many Europeans, not only in the superior ranks, but also as guards, engine-drivers, foremen, etc. On canals nearly the whole of the establishment employed is native, with the exception of the few European officers. There is a whole army of *patwàris*, gauge readers, patrols, as well as clerks, secretaries, and other functionaries exclusively employed in office work.

But, unfortunately, there is one dark shade across a very bright picture. The service of the Irrigation Department, lofty in its scientific aims and splendid in its results, is a most unpopular one among European engineers. The life, as we have pointed out, is lonely and exposed. A man, not unnaturally, desires some social or domestic relaxation from official cares, and in no branch of the Public Works Department does he get so little of these. There is practically no corresponding compensation in the matter of emolument. However skilful or scientific, the Indian civil engineer cannot command the price for his brain work that his compeer in practice in England can: I am speaking, of course, of those who are at the top of their profession in both countries. Nor is there any chance of the Indian civil engineer nowadays obtaining any of the rich administrative appointments open to the covenanted Civil Service. It was different in the case of the military engineers who were the early pioneers of this work. Sir Henry Durand, for example, rose to be Lieutenant-Governor of the Punjab, and Lord Napier of Magdala became Commander-in-Chief in India, and subsequently Governor of Gibraltar. With these and other celebrated military engineers the case was somewhat different from that to-day of the civil engineers by whose skill these great canals have for the most part been built. They have practically no other career before them. A turn in fortune's wheel might take a soldier engineer away from his canal to a campaign where honour and advancement await him, but the civilian comrade with whom he has been working has to stay on at his steady work, with very little prospect before him, except that he knows he must retire at an age when his experience is most mature and his knowledge of the country most extensive. He knows also that, with the exception of Egypt and America, his skill and experience will not find a market in other parts of the world, and though he may be listened to with the utmost respect at the headquarters of the Institution of Civil Engineers at Westminster, he will find no scope in England for actual practice. Little wonder, therefore, that he endeavours to obtain a transfer from work so unremunerative, and to follow his compeers at Cooper's Hill or Roorkee into railways or some other less specialized branch of their profession.

There is also the feeling that the work is not appreciated,—that the very art which has concealed the art of scientific canal design has been so effectual that the lay mind has come to think there is no art at all.

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This feeling of bitterness may be unfair, but it unquestionably exists; and it must be admitted that there have been certain incidents which have given grounds for it. When a colossal work like the Chenab Canal was opened, one might have thought that the occasion was one for a little *éclat*, and possibly the bestowal of some marks of honour by the representative of the Sovereign. When the Glasgow Waterworks were opened in 1859, Queen Victoria, at some personal inconvenience to herself, graced the occasion with her presence, and gave proofs of her appreciation to those principally concerned. But no Viceroy of India went near the Chenab Canal for some six years after its opening. When at last one did visit the place, and there was a good deal of high falutin about the desert blossoming—which was true, if not very original,—the next Honours Gazette contained no reward whatever for any engineer. There was a decoration given, but it was to the colonization officer who had arranged for the transplanting of families from the congested districts to the new area. Very probably this officer had done his work, and deserved his honour; most thoroughly. But to reward him only was, as the principal Lahore newspaper severely said, as though, in opening a large public building by the Sovereign, the architect had been ignored and only the lawyer who drew up the deed of occupancy had been noticed. It is needless to say that the private comments on this occasion were forcible and caustic.

That the rulers of the Punjab fully appreciate the loyal and conscientious service of the canal engineers is evinced by many public utterances of successive Lieutenant-Governors. It is understood that quite recently improvements in pay, etc., have been made, which will alleviate the bitterness above alluded to. No doubt the Government has carefully considered how best to put the matter on a more satisfactory footing, and that being the case, it would be impertinent for an onlooker, however cognizant of the facts from within, and however sympathetic, to suggest a remedy. But no account of canal work in the Punjab, however fragmentary, would be true without some allusion to this subject. In a work so interwoven with the welfare of the people, and involving such large sums of money, dissatisfaction among the workers is a serious national question. There are to-day in progress further schemes still vaster than any which have hitherto been accomplished, and to leave the working out of these in any but the best hands would be a national calamity.

(*To be concluded*).

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NOTICES OF MAGAZINES.

Engineering News.

1st January, 1914.

Bituminous Surface Treatment of Macadam Roads.

During the year 1913 the Bureau of Highways of Philadelphia treated 415,000 sq. yards of water-bound macadam roads with bituminous materials with satisfactory results. Preparation of the road has an important bearing on the success of the treatment. Dust and dirt were removed by machine sweepers, scrapers and hand brooms. The surface dressing used was clean sharp sand or rock chippings passing a $\frac{3}{8}$-in. screen. The average amount used was 25 lbs. per sq. yard.

The bituminous material used consisted of 65 per cent. asphalt and 35 per cent. commercial naphtha, 53—55 Baume. This was applied cold, about $\frac{1}{3}$ to $\frac{1}{2}$ U.S. gallon being used per sq. yard. The naphtha assisted penetration, which was usually about $\frac{3}{4}$ in. if the weather was not too cold. Whenever possible the treated surface was allowed to stand 24 hours before the application of the top dressing, but where traffic conditions did not allow this to be done the top dressing was applied before stopping work for the day. The surface dressing was afterwards ignited to burn out the naphtha, which caused immediate setting of the asphalt. Very little penetration can be secured in cold weather, so that all work of this nature should be done in the summer. Care should be taken that surplus bituminous material is not left on the surface after maximum penetration has been secured, as this forms a plastic pad which creeps and forms pits.

8th January, 1914.

The Hell Gate Steel Arch Bridge.

This bridge is of special interest on account of its size, its massive structure and its large capacity. It is a double-chord parabolic arch, 40 ft. deep at the crown and 140 ft. deep over the abutments. The span is 977 ft. 6 in. and the rise of the lower chord is 220 ft. The arch is divided vertically into 23 panels of equal length. The roadway is partly suspended, the 17 centre panels being below the lower chord. The bracing is very complete. Each chord has its own system of cross-bracing and the two trusses are cross-braced vertically at the panel points. The roadway is separately braced for wind load and traction and breaking stresses.

The bridge carries four lines of standard-gauge railway track. The dead load of the bridge averages 53,000 lbs. per foot-run. Impact is

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allowed for in accordance with Lindenthal's impact formula (*Engineering News*, August 1st, 1912), which is

$$I = \frac{L^2}{L+D} \times \frac{8Q+qa}{4Q+4qa}$$

where I = stress equivalent of the impact.
L = live load stress.
D = dead load stress.
Q = weight of locomotives and tenders.
q = weight of train behind tender.

This bridge is now being constructed in the shops and will be erected during the coming summer.

VALUATION OF THE SEWERS OF MANHATTAN BOROUGH, NEW YORK CITY.

The report on this work shows that the average life of a brick sewer is 64 years, *i.e.*, after this period it is uneconomical to continue repairs, and replacement is necessary. Most of the failures, as tabulated, appear to be due to insufficient lateral support. This points to the advisability, in design, of considering the top of the sewer as an arch and the bottom as the abutments thereto. In pipe sewers there was no wear due to length of service. The principal causes of failure were depressed joints, and breakage of the pipe, which latter, however, only occurred at and above the centre, due, probably, to the super-imposed load.

15th January, 1914.

SAFE OPERATION OF REDUCED SPEED SECTIONS OF RAILWAYS.

A paper by a German Engineer in the *Bulletin of the International Railway Congress* discusses the requirements for permanent and temporary speed reduction points on railways. These may be summarized as follows (many of the comments were suggested by reading the article) :—

1. There should be as few reduced speed places as possible. The necessity for this is shown by the large number of permanent speed reduction places published in the instructions issued to railway employees (over 1,000 on L.N.W.R.).

2. There should be as few varieties of reduced speed as possible This can be realized on curves by providing the proper super-elevation, and at switches by restricting the frogs used to as few varieties as possible.

3. Reduced speed places should be properly marked ; the permanent ones by a notice board, illuminated at night if necessary, on which is plainly shown the speed allowed ; temporary ones, in addition, by specia signals, day and night, placed at each end of the section referred to One method of doing this is to use a temporary distant signal fixed at danger at the beginning of the section, and a temporary stop signal in the " off " position at the end of the section. Temporary reductions should be eliminated at night as far as possible, if the nature of the work will admit. Care should be taken that the locomotive men are kept informed of the temporary reduced speed places.

4. The schedule should allow extra time for reduction of speed and no blame should attach to the driver if he is compelled to lose time in consequence of speed reduction places.

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5. All locomotives should be fitted with direct-reading recording-speed indicators, which, in conjunction with occasional tests by officials, would ensure that instructions are obeyed.

6. If the number of speed reductions on any line is excessive it indicates that the schedule is too high or that the line requires to be reconstructed.

W. G. TYRRELL.

REVUE MILITAIRE.

August, 1913.

THE NEW GERMAN ARMY LAW OF 2ND JULY, 1913.

The additional engineer details to be provided are :—

Three new battalions (2 fortress).

Nine fortress regiments formed, one from the 2 Bavarian battalions, 8 from 8 battalions and 8 headquarters of existing corps engineers.

Nine searchlight detachments attached to the above regiments.

One siege unit.

Two Bavarian companies to complete establishment.

25 battalions of field engineers to be increased by 3 N.C.O.'s and 30 men each.

26 searchlight squads to be converted into detachments.

The field and fortress units will henceforth be separated, and the latter will be composed of the above-mentioned 9 regiments each with its siege train and searchlight detachment stationed probably at Königsberg, Grandenz, Posen, Cologne, Coblenz, Mayence, Metz, Strasburg, and Ingolstadt. Each of the 2 battalions per regiment will have 3 companies. Since the existing battalions have 4, only 2 remain to be provided. It is noticeable that the searchlights with an Army Corps are doubled, and that the Germans lay great stress on their use. There are increases in telegraph, telephone, and wireless telegraphy units. Three battalions and 3 odd companies are to be added to the flying corps which will now consist of 6 battalions (17 companies). With the exception of 2 battalions, they are to be allotted to dirigibles and stationed at Düsseldorf, Cologne, Mannheim, Darmstadt, Lohr, and Friedrichshafen on the western frontier; Königsberg, Grandenz and Schneidemühl on the eastern frontier, and Hanover, Dresden and Munich in the interior; at each of these places there will be a double rotating shed, providing in all for 30 dirigibles. The aeroplane companies will be redistributed between the following stations :—Döberitz (2), Zeetham, Posen, Grandenz, Königsberg, Cologne, Hanover, Darmstadt, Metz, Strasburg, and Fribourg with 2 in Bavaria.

The organization of the Norwegian Army is described.

FOREIGN INTELLIGENCE.

Belgium.—In accordance with the new army law the strength of the army will be raised from 251,000 (the maximum foreseen by the old law) to 340,000 of which 150,000 will form the field army, the remainder being part detailed to the fortresses of Antwerp, Liège and Namur (130,000), and part reserve and auxiliary units.

E.R.

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CORRESPONDENCE.

THE SIPHON AS AN AID TO WATER SUPPLY

DEAR SIR,

With reference to H.K.'s letter, which I have only just noticed in the February *R.E. Journal*, on the above subject, I am very grateful to him for pointing out an error in *Plate* I. accompanying my article in the January number.

The stopcock at the junction C in sectional elevation AC should be called No. 3, as it is in sectional elevation BC. Stopcock No. 2 is at the head of Siphon B.

It would no doubt be possible, with a good pump, to start a siphonage action in the 2-in. pipe at Sierra Leone by the arrangement he suggests; but it would be quite impossible to extract all the air from the pipe by this method with such a difference in levels; and since air in the siphon reduces its output, and gradually stops it, I do not think it would continue to run for long.

It is one of the first essentials for efficient working of a siphon that it should be free from air, and the airlock was devised as the easiest means of starting and keeping it as far as possible in this condition with the plant and materials available.

H.K.'s arrangement makes no provision for preventing air accumulating at the head of the siphon, or for extracting it while the siphon is working. His $\frac{3}{4}$-in. pipe required restarting after some hours of working; I am afraid the 2-in. pipe at Sierra Leone (which contains 30 times as much as his) would, with his method, require almost constant attention, and this it was my chief aim to avoid, if the siphon was to justify its existence.

The expense of some extra 2-in. stopcocks is I think more than compensated by the saving in labour.

Yours truly,

E. W. S. MAHON.

23rd February, 1914.

The Editor, *R.E. Journal.*

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NOTES ON ROYAL ENGINEER WORK AT SIERRA LEONE, WEST COAST OF AFRICA, 1911–13.

ALMOST all the work is in, and around, Freetown, but there are three stations in the Protectorate, namely Port Lokko about 40 miles by launch from Freetown, Mabanta 23 miles north of Port Lokko, and Wankifu 18 miles north of Mabanta.

Freetown, the chief town of the Colony, is surrounded by a semi-circle of hills—the remains of the crater of an extinct volcano having a diameter of about 4 or 5 miles with Freetown as its centre.

Tower Hill is a conical hill nearly 400 ft. high, clear of bush and about 3½ miles east of the sea.

Mount Aureol is about 1½ miles east of Tower Hill, 800 ft. high, and extends towards Kortright Hill, 1,000 ft. high.

Wilberforce is 2½ miles south-west of Tower Hill—600 ft. high. A light railway runs from Freetown to Wilberforce (Hill Station) but the trains are infrequent, inconvenient, and slow. Generally, to get to Wilberforce from Mount Aureol one has to descend 700 ft. and rise 500 ft. in a distance of about 5 miles by road.

King Tom is about 1½ miles north-west of Tower Hill on a small cape.

Personnel.—The O.C.R.E. is generally a Major and has the ordinary C.R.E.'s power. The G.O.C. is also M.G.A. of the Company Officers; the C.O. is generally D.O. Tower Hill. The O. i/c E.L. has the East or Mount Aureol Division, and is O. i/c R.E. Stores and commands the Right (European) Half-Company. The other subaltern commands the Left (Native) Half-Company and is D.O. West (Wilberforce) and 1st Line Defences.

The Staff for R.E. Services include :—

At Head Quarters.—An A.I.W. generally a S.M. F. of Works, 1 engineer clerk, 2 draughtsmen, 1 storekeeper, 1 ledgerkeeper, 1 mechanist machinery, 1 mechanist electrician, 1 mechanist telephonist. There are 5 foremen of works, usually distributed as under :—1 Tower Hill, 1 Mount Aureol, 2 Wilberforce, 1 Protectorate. The two at Wilberforce are necessary on account of the distance, but one acts as a reserve in the event of sickness among the others.

Soil.—The soil consists entirely of syenite slabs and boulders, and laterite rock and earth ; the boulders are always found surrounded by laterite, and it is rare that an excavation of any extent can be made in laterite soil without coming on large syenite boulders weighing many tons. Extreme care should be taken in estimating

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for excavation, for it is impossible to foretell with any accuracy the amount of syenite lying below ground. It is often practically a solid mass of igneous rock.

The rocks can be bored and blasted, but even then are generally in such large lumps that they cannot be moved; they are further split up by building a wood fire on top and throwing water over them when hot.

Water.—The soil is porous and the laterite acts as a natural reservoir or sponge, being refilled each rainy season and delivering up its yield gradually during the remainder of the year. Until March most of the water courses have a good flow of water, during April the flow diminishes gradually, and during May and until the tornadoes arrive in June the supply from the surface is decidedly scanty.

Owing to the porosity of the soil and the steep faces of the slopes, impoundage is practically impossible, and the system adopted is to place quite small dams at various likely positions (for choice close to a bit of impermeable rock) and to bring the water direct by pipe to storage reservoir close to the town.

For W.D. supplies there are three systems, each with a reserved collecting area closed to the troops and the public.

These are :—

(1). Tower Hill Supply—in the White Water Ravine. The supply here has recently been considerably augmented by boring.

(2). For Mount Aureol and Kortright, in the Gloucester Collecting Area. The method of collection has recently been improved and the supply considerably augmented—more can probably be done in this connection.

(3). The Wilberforce Supply—from the Regent Collecting Area. This supply is very scanty after April and boring should be made close to the dam to supplement the amount. (In cases where borings are used to tap the natural reservoirs care should be taken that they should not be drawn upon except when the need actually exists, otherwise there is a chance of the reservoirs being prematurely exhausted).

Building Materials.—The syenite is extremely close grained and hard. At Hill Station it appears harder than at Mount Aureol. It has been used for building in ashlar and rubble, but is very hard to dress and is more usually used now as the aggregate for concrete and concrete blocks.

The laterite is soft and can be easily cut into blocks for building. It weathers hard but always remains somewhat porous. It is also used for aggregate, and does well where no excessive weight is likely

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to be put on it ; as a rule weathered laterite should be used as it is harder ; the ordinary rock if broken up crumbles somewhat and needs sifting and cleaning. The syenite is very costly to break up for concrete.

Sand is obtained from the seashore. It costs practically nothing to collect, but as it has to be transported distances varying from 2 to 4 miles and sometimes to 1,000 ft. above sea level, the transport charges are enormous. There is no limestone in the country. All lime has to be imported from the United Kingdom.

There is good local timber to be obtained, but it has to be brought from such a long distance that the cost is excessive and recourse is had to the United Kingdom instead. Small quantities of scantlings of fir and deal can be obtained locally, also weather boarding and match boarding.

For native huts the best poles procurable are mangrove and monkey apple—both very heavy and not attractive to white ants and " bug-a-bug " (a boring insect). They are excessively dear, *i.e.* 8s. to 12s. a dozen, if bought from local purveyor, but can be obtained for 2s. to 3s. per dozen if cut in W.D. reserved catchment areas and brought in by the troops on working pay.

There are no local manufactures and not much in the way of local purchases. Almost all stores of steel, iron and small material have to be procured from the United Kingdom on indent. Small quantities of corrugated-iron sheets can be obtained locally, but it is rarely of thicker gauge than 26 S.W.G. A few small stores such as screws, glass, paint can also be purchased, and it is sometimes possible to purchase from the P.W.D.

Stores.—The general procedure for stores is for the O. i/c of Stores to submit demands for Class A and B Stores annually in April, and they are procured through the A.O.D. E.L. and T. Stores are indented for annually in August.

For other stores the A.I.W. abstracts from each estimate those necessary, and indents direct on the War Office for them. These are sent out to Sierra Leone, consigned to the A.O.D. who clear them and hand them over to the R.E. on the Wharf. The A.S.C. provides transport on requisition by the R.E. There is generally a small reserve of Portland cement which can be drawn against for small works, and repaid when received from the United Kingdom, and quite lately sanction has been received to a reserve of £300 worth of stores to be similarly drawn against. *Care must be taken that repayments are punctually made.* The object of this is to lessen delay, and also to lessen the number of small indents which are continually being submitted to the United Kingdom. When the new system is in working order, a monthly or bi-monthly comprehensive indent for small works can be submitted which will lessen work both in the Colony and United Kingdom.

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As before mentioned some stores can be procured locally and there are four firms who tender. Prices rule about the same as those supplied by the War Office.

Joinery has recently been made up by the S.M.E. It is of good quality and possibly a little cheaper than if made up locally. A point to be noted is that panelled work should be made up diagonally, *i.e.* the panel boarding should be put diagonally (*vide* Indian pattern type drawings), it is less likely to split. It must be remembered that the extremes of dryness and humidity are excessive, and no woodwork can stand with impunity the extreme dryness of the Harmattan wind and the damp of the rest of the year.

It is thought that some of the jalousie work is unduly solid :— the louvres might be thinner. Where light is required and where the jalousies are fixed or sliding, glass can be substituted for wooden louvres with success and economy.

A good deal of concrete work goes on, involving sometimes a considerable amount of casing. Some of this wears out, but it appears to have been the practice to use up any stuff that survived on incidental work. It is brought on charge and should all be marked. This will save having to estimate for the full amount required in each work where casing is required.

Nature of Buildings and Rough Specifications.—The buildings of old date at Tower Hill have walls of brick, some few of syenite and others of laterite, many are wooden buildings weather boarded, and lined with match board. Of late, reinforced concrete and concrete blocks have been used with success for the walls. The best and most economical will probably be the concrete blocks made with laterite aggregate, this will render steel framing unnecessary. One Winget machine is in work. A concrete mixing machine and engine is also on order.

All dwellings require, from the nature of the soil and climate, to be raised from the ground ; a height of from 2 to 3 ft. is sufficient. A concrete " seal " is laid on the surface of the ground ; in former buildings one finds this " seal " made of 4 to 6 in. of p.c. concrete with a rendered surface—this appears unnecessary. If 2 in. of laterite metal be well rammed and the surface dressed while ramming with old concrete rubbish or with a skin of cement and sand, it should be quite sufficient—and the same applies to plinth protection on the ground from 3 to 4 ft. round the walls. The practice has been to provide eaves guttering and down pipes with elaborate and deep drains to take away the roof water ; this is unnecessary ; small depressions sometimes occur in the eaves gutters and form a possible breeding place for mosquitoes. The soil will absorb most of the rain, if the plinth protection is given. The eaves gutters in most cases can be dispensed with, and the only drains really necessary are those for foul water. These should be saucer-shaped ; a number of old

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slates from dismantled roofs have lately been obtained, and these make admirable bottoms for such drains. Concrete is not desirable for the bottom of drains which have to be swept out, or for those of any steepness; the concrete gets worn out very quickly (see Roads and Drains).

Floors.—These are best made of concrete reinforced either by expanded metal or bars. Floors and also the walls have to be supported on R.S. joists or concrete beams. Much of the steel work found in former designs can be dispensed with, *e.g.* the joists can be laid direct on concrete piers—small columns 2 to 3 ft. high on top of piers are quite unnecessary.

Roofs.—The older roofs have wooden trusses—these can advantageously be of steel in the future, fixed direct on the concrete block walls with steel bedplates or shoes bolted down to the walls; steel columns are quite unnecessary unless reinforced concrete panels are used, and this can only be economically done (if then) if the walls are not more than 4 in. thick; such walls should be sheltered from the weather, even 6 in. is hardly thick enough to keep out the damp.

Roof Coverings.—These were formerly of slate, but this kind of roof has now practically disappeared. Experiments have been made with asbestos sheets laid on boards with felt between. The P.W.D. used them extensively and found them a failure, and are now re-covering practically new buildings with C.I. sheeting. Only two R.E. buildings have these roofs; both have been laid less than six months, one appears so far satisfactory but in the other, though remaining water-tight, the slates appear to have buckled or crept and a series of undulations have appeared. Corrugated-iron sheeting on the whole is the best roof covering; it should be painted after being up about a year when a small amount of rust has formed. Reinforced concrete roofs would no doubt be desirable but labour is not sufficiently skilful nor plant adequate to make these in large panels to be water-tight.

Preservation of Ironwork.—It is very extraordinary how the ironwork in Sierra Leone resists rusting influences in spite of the prevailing damp and exposure to sea air. It may possibly be due to a deficiency of ozone and nitric acid, there being no seaweed to give these off. Oxide paint seems to fulfil all requirements for joists and roofs; the latter should be slightly rusted before the paint is applied strange as it may seem. A good receipt is to sprinkle sand over the wet paint, or to paint the joists with thick cement grouting, especially if a little rusted.

For native troops, huts are constructed—these consist at present, as regards the walls, of poles filled in with wattling and mudded over —the roof being formed of poles 2½ to 2 in. thick or less with battens over, and very thin corrugated-iron sheets. The huts are in bad repair, and a new type of design with steel frames have been approved. The sheets should be of considerably stouter gauge.

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As a rule roofs, doors and windows are kept up by the R.E. and the mud walls by the troops at their expense.

General Design.—Most of the buildings are too low, the height of the rooms should seldom be less than 11 ft. even in Wilberforce and Hill Station. In single-storied buildings ceilings should be omitted. There should be louvred ventilators in gables to bring a draught through the underside of the roof.

Eaves should be wide as the drift of the rain is very great; tornadoes come from the N.E. to begin with, but the direction changes through a wide angle, so the northern sides of houses should be specially protected.

The prevailing winds are:—November to March—North-East; April to July—South-West; August to October—West.

Labour.—No contractors for work exist in the Colony, though some English firms have made enquiries. All work therefore has to be done by direct labour, and constant supervision by the M.F.W.'s is necessary. Time sheets are to a large extent useless as most of the men cannot read or write, and the only check is by accurately estimating and constantly checking the estimate with the progress; it is not easy to get English-trained M.F.W.'s to do this. The native foremen are unreliable and the artisans of indifferent quality. The labour is excessive in cost and unsatisfactory; the negroes will not work unless compelled and constantly watched.

During the last year or so the prosperity of the country has gone up by leaps and bounds, with the result that both the trading community and the Colonial Government are extending their buildings rapidly; consequently labour is difficult to procure and unsatisfactory when obtained owing to competition in rates. The rates have gone up from 10 to 15 per cent. lately, and may be reckoned on rising for some time to come.

As regards the labourers, they are men who come into Freetown for work when nothing can be done on their farms, and at sowing and harvest time they all troop back to their homes for farming purposes leaving but few in Freetown. Even in the Protectorate close to their homes their services cannot be relied on, and labour is scarce all the year round.

The Sappers both European and Native are employed on the works, and the troops, especially those in the Protectorate, are also employed and receive working pay.

Labour is generally scarce from February to April and again from July to October. In the latter case it does not so much matter as not much work can be done during the rain, but the former period interferes with the end of the financial year and as much work as possible should be carried out during April, May and June.

Estimates.—Very considerable care needs to be taken in framing even approximate or cube-rate estimates. Recently the cost of both

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material and labour has considerably appreciated, and former prices are not much as a guide unless 15 per cent. is added. The schedule of rates will shortly need complete revision, but as most of the items are framed for labour only, it is not much good reprinting until some finality as to cost of labour can be foreseen.

Estimates are taken out showing :—

(*a*). Cost of labour only.
(*b*). Cost of material only.

It is advisable to send any large estimate to have W.O. for check when forwarding indents for materials, and to ask that the actual cost of same be compared with the estimated cost so that any considerable difference may be detected at once and precautions taken to avoid excesses.

As contractors' measurements are not taken, the A.I.W.'s estimate for quantities should, as a rule, be sufficiently exact to cover the cost of the work, and to facilitate check of cost of work in progress by the D.O. or M.F.W.

Roads and Drains.—The roads throughout Freetown are practically ungraded and unmetalled. They follow the surface of the ground, generally by the nearest route, so that in places the gradient is very excessive.

All the important roads can be treated as hill roads and are unmetalled. Those belonging to the W.D. are few and the mileage small. The broader ones have inside ditches with cross-drains. On the steep grades the roads get badly eroded unless stone ridges are built across them to turn the water to the drains.

On narrow roads the same ridges are advisable, but it will be found more satisfactory to make the slope outwards and to construct a catch-water drain on the hillside above the road; this need not be lined with stone or concrete.

The roadside drains have been made deep and square, in some places the gradients are absorbed by stepping, but in others they follow the gradient. This latter is most unsound, the heavy rains bring down quantities of débris and small stones ; and these moving rapidly over the bottom erode a concrete surface very quickly, and considerably damage even a laterite bottom. It is essential to step the drains and to make the bottom of slate or rock—the riser should be sloped about 30 degrees out of the perpendicular. The drains could with advantage be made much shallower and possibly wider.

The Public Works have under consideration a large scheme for improving the roads in Freetown for wheeled (*i.e.* motor) traffic. and the necessity must be reckoned with of bringing the few W.D. roads into line at no very distant date—such means of locomotion will undoubtedly much reduce the present heavy transport charges for carriers.

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Tree Planting.—In the vicinity of some of the W.D. buildings, *e.g.* at Tower Hill and Mount Aureol, the bush has been cut with so much thoroughness that all the trees have also been removed. This is not altogether desirable, a few trees are needed for shade to roads and to improve the landscape. Recently trees, chiefly of the rubber species, have been planted along some of the roads ; and this should be continued yearly. They should be planted early in August.

Names of the best and quickest-growing species can be obtained from the Conservator of Forests, who also very kindly will supply young trees from his nurseries when available.

A hole should be excavated and filled in with good soil, and guards should be placed round them to prevent damage from cattle and goats ; the inhabitants of Freetown have the grazing rights over Tower Hill. When planted near buildings, care should be taken to place the trees so that the branches will not overhang them.

Care is needed at the commencement of the dry season in February to prevent the young trees being destroyed when the grass is burnt ; small areas should be cleared round each tree in December.

Climate as it affects Works.—There is but small variation in the climate. The mean temperature varies as a rule between 65 and 95 degrees. This is favourable for concrete work and expansion joints are hardly necessary, nor, except for very long spans need provision be made for expansion in ironwork.

The dampness is exceptionally favourable for good results in concrete.

Rain falls heavily during the latter half of June, July, August and September—it is preceded and followed by violent tornadoes and precautions must be taken against high winds.

During December, January and February the Harmattan blows—this is an exceedingly dry wind from the desert to the N.E. and is heavily loaded with fine particles of sand ; it dries up and shrinks woodwork and destroys the qualities of leather, rubber, and tar materials such as felt.

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REVENUE AND CADASTRAL SURVEYS.

By CAPT. H. G. LYONS, F.R.S., LATE R.E.

UNDER the general term "Surveying," are included the measurements of the earth's surface which are made for many purposes; for each of these special factors are of primary importance, and the precise methods employed have to be selected accordingly; but there is no branch of the subject which has a wider bearing or a greater importance than the measurement and demarcation of landed property which is comprised under the terms Cadastral and Revenue Surveys. In each of these the size, shape, and location of each landowner's property have to be determined, and considerable precision is demanded especially in cadastral work. There is a well-defined difference in the scope of these two classes of survey when the terms are employed in their strict sense, for while the ownership, size, and the quality of the land of each holding suffice for the most part for a Revenue Survey, which has for its object the equitable imposition and ready collection of a land tax, a cadastre is required to provide a full record of all claims, servitudes, and evidence of ownership as well, so that it may establish the owner's title to the property. Under certain conditions the one may pass by gradual development or by a subsequent revision into the other, but in any case the determination of property boundaries, which can usually be indicated with precision, demands work of a high order if the measurement of many thousands of small holdings is to be so controlled as to maintain a high standard of accuracy. It is not necessary to discuss at length the disputed derivation of the word "cadastre," but as strictly used it connotes a record of individual holdings, their size. location, and character, their ownership, and all rights and liabilities connected with them, so that their measurement and the graphical record of such measurements on a map or plan is only a portion, though a very important portion, of the information needed. At the same time the map is not an essential part of a cadastre although it is now almost invariably associated with it; but whenever it is prepared it must show primarily the boundaries of properties irrespective of their relation to topographical features. Hence the 1 : 2,500 maps of the Ordnance Survey are not true cadastral maps, but are large-scale topographical maps since the details that they show, walls, hedges, railings, etc., are topographical features which may not and do not in every case coincide precisely with the property boundaries.

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These classes of survey are not at the present time officially represented in this country, though in most European countries, in the Oversea Dominions and in many Crown Colonies, they are of extreme importance, and, as a special application of the principles of land measurement, they merit more attention here than they have usually received; for in their employment over large areas, or in densely populated districts, they demand work of the highest precision that can be executed in order that the exact location of each holding may be adequately controlled.

In most European countries the great State Surveys, in their present form, date from about a century and a-half ago, and owe their inception rather to the military needs of the State at that time, than to fiscal requirements. Consequently their first basis was essentially topographical, and their object was to produce maps of sufficient detail and accuracy to facilitate the movement of bodies of troops through the country, and to indicate the tactical positions available. Large-scale maps were not therefore at first essential, and it was only later on when administrative needs became urgent that these were undertaken. In this country we are still in this position, for the recent enlargements of the 1 : 2,500 map, which have been produced to facilitate the valuation of land for the purposes of land tax, can hardly be regarded as a Revenue Survey properly so-called.

On the Continent most countries have long had land surveys of a local character, but it was not until the 18th century that any steps were taken for the control of these by triangulation of the highest accuracy carried out by the State. As the outcome of this Germany, Austria, Italy, Holland and Belgium have now detailed surveys of all landed property, which are being constantly revised and brought up to date, and which consequently demand the services of a large profession of surveyors who are constantly engaged in land measurement of high precision. In France the matter has not yet proceeded so far. The " cadastre " of Napoleon's time is still in use, and though a Commission has been studying the question for many years and has reported voluminously upon it, no Cadastral Survey of the whole of France yet exists as a single co-ordinated piece of work.

The essential difference between Cadastral and Topographical Surveys is to be found in the fact that the former are concerned with locating the boundaries of landed property, while the latter indicate the boundaries of natural features, and the visible results of man's handiwork on the earth's surface, a distinction which is intimately related to the methods of work, for property boundaries can be defined much more precisely than such natural limits as a seashore, the bank of a river, the foot of a hill, or the floor of a valley. Much more accurate methods may therefore be employed, and wherever landed property is situated in densely populated tracts its value is greatly enhanced, so that the highest precision is demanded in its

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demarcation. For this reason Cadastral Surveys justify the additional expenditure incurred in executing a triangulation of the greatest accuracy, and work of such a character as to contribute to the solution of the highest problems of geodesy can be profitably utilized in controlling the various grades of measurement which go to determining the location of the boundary marks of individual holdings.

Thus, in Cadastral Surveys, the scale of the map, and consequently the methods of surveying to be employed, are controlled by the value of the land which is being measured, or perhaps, to speak more correctly, by the size of the plots or holdings into which it is subdivided. The scale selected must therefore be large enough for the purposes of the cadastre, and is in most cases larger than that which is required for the topographical maps of the same district, so that the term cadastral is often used to designate a large-scale survey of land in which the boundaries of each holding and plot are located accurately by measurements, whether they coincide with topographical boundaries or are marked artificially, or are even without any visible indication, that is to say cadastral maps are governed by special conditions which do not occur in the case of maps which are designed for purely topographical purposes. In most European countries, they may be described as being maps on a large scale which form the basis on which the State land tax is regulated, and they are to be considered as legal documents relating to the possession, the cultivation, the employment and the value of land. For this reason it is essential that the whole of the work should rest securely on actual measurements, and not be sketched in ; all observations must be recorded and be available for subsequent verification, so that graphical triangulation with the plane table is undesirable ; numerous permanent marks must be provided so that changes, encroachments, and subdivision of holdings can be rapidly and accurately effected at any time.

With this object, a very close network of triangulation is executed in connection with the triangulation points of the main survey of the country, and a complete measurement based upon them is carried out by very careful determinations of length and angle. Theodolite traverses increase greatly the number of permanently marked points of reference which the triangulation provides, and in the field the detail measurements are recorded in dimensioned plans drawn to scale which are preserved as the original documents, and from this material the cadastral maps are prepared. These are essentially prepared as site plans, that is, they do not indicate the natural form of the ground, nor do they show heights, depths or slopes, while the scale varies with the size, cultivation and importance of the area measured, such scales as 1 : 500, 1 : 2,000, and exceptionally, 1 : 4,000 being employed. A Cadastral Survey is sometimes carried out

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over the whole of a country as a single piece of work, but it is oftener executed by villages or other administrative areas; the maps in such cases are prepared by villages, several sheets being used if necessary. In consequence of the accuracy with which small details are measured up and plotted, cadastral maps of all kinds, field, forest, river and town maps are well suited for supplying a basis for the cartographical representation of a country, and may be reduced to any smaller scale, revised, completed in relief features and brought up to date to form topographical maps. This description applies more strictly to the Cadastral Surveys of Germany, but may be extended with but little modification to those of the other European countries, the essential condition of a cadastral map being that it should show the boundaries of property, whether these coincide with the topographical features or not.

While therefore a cadastral map is one which shows property boundaries and in which topographical features are considered as being of secondary importance, it is not essential that the scale should always be large, for it will depend mainly upon the extent to which the land is subdivided and partly also upon its value. Where the land is owned in large tracts and is of little value, a comparatively small one may suffice. As a rule the scale to be selected for any area is determined by the average size of the holdings according to certain rules, and in Prussia, these are :—If the average size of the plot is greater than 0·5 of a hectare the scale used is $\frac{1}{2000}$; from 0·05 to 0·5 of a hectare, $\frac{1}{1000}$; if less than 0·05, $\frac{1}{500}$; whilst for wood, marshes, waste areas and lakes a scale of $\frac{1}{4000}$ is used.

The original scale of the Austrian cadastre was 1 Vienna inch ($\frac{1}{72}$ of a Vienna klafter) to 40 klafter, or 1 : 2,880; cities and the larger towns were mapped on the scale of 1 : 1,440, as also was land which was divided into small plots; in Vienna the scale of 1 : 720 was also employed. In 1873, when the metric measures were introduced into all branches of the public service, the scale of 1 : 2,500 was introduced for all future surveys. In cases where the land is highly subdivided, the maps are plotted to the scales of 1 : 1,250, or 1 : 625.*

In Würtemberg the normal scale is 1 : 2,500, but 1 : 1,250 is used near towns and villages where the holdings are small. At the same time most countries adopt one scale as that to be used wherever there is no good reason for the use of a special one, and in Europe this is usually 1 : 2,500, or some scale approaching this.† But the adoption of a single scale throughout a large area would usually be unsuitable, since it would probably be extravagantly large for the scantily

* *Instruktion zür Ausfuhrung der Vermessungen . . . für die Zwecke des Grundsteuerkatasters.* Wien, 1907.

† *Amts-Blatt des Königlich Württembergischen Steuerkollegiums* No. 2. Stuttgart, 1895.

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populated districts, and inconveniently small for the towns and cities. A tabular summary of the scales in use in certain countries is given below :—

Scales in Use for Cadastral Maps.

Prussia.	Würtemberg.	Bavaria.	Baden.	Saxony.	Austria.	Italy.
—	—	1 : 5,000	—	—	—	—
1 : 4,000	—	—	1 : 4,000	—	—	1 : 4,000
—	—	—	—	—	1 : 2,880	—
—	1 : 2,500	1 : 2,500	—	—	1 : 2,500	—
1 : 2,000	—	—	1 : 2,000	1 : 2,000	1 : 2,000	1 : 2,000
—	—	—	1 : 1,500	—	—	—
—	1 : 1,250	1 : 1,250	—	—	1 : 1,250	—
1 : 1,000	—	—	1 : 1,000	1 : 1,000	1 : 1,000	1 : 1,000
—	—	—	1 : 750	1 : 750	—	—
—	—	—	—	—	1 : 625	—
1 : 500	—	—	1 : 500	1 : 500	—	1 : 500
—	—	—	—	1 : 200	—	—

The accurate measurement of landed property is older than any topographical survey, and it had already in the earliest historical times reached a very advanced stage in those regions where human civilization was most highly developed. In the very early times of Egyptian history a "numbering" of the Royal possessions was made throughout the land by the officials of the treasury every two years, and this would be a sort of verificatory survey of State property which doubtless included herds as well as lands. This biennial census was so regular a procedure of the administration in these early times that events in the reign of the king were dated with reference to it.

A little later we meet with records of the registration of property, for in the third dynasty, about 3000 B.C., the property of a high official Methen,* was recorded on the walls of his tomb at Saqqara, and is stated to have been duly registered as belonging to him in the royal archives or registry. There must, therefore, have been at this time a well-developed method of measuring the land and of computing the area of properties. It was not long before the registration of land and its measurement became highly organized, as would be essential in a country where all payments of taxes were made in kind and rent was paid in the same way.

Another of the tombs of Saqqara, that of a certain Mes,† furnishes us with information of exceptional interest. Certain lands near Memphis which the Pharaoh Amosis (1580 B.C.) had conferred on an ancestor of Mes named Neshi were, during the minority of Mes

* Breasted, *Ancient Records*, Chicago, pp. 171–5.

† Loret, *Ægyptische Zeitschrift*, 39 (1901), Moret, *ibid;* Gardiner, *The Inscription of Mes, Untersuchungen zur Geschichte und Alterthumskunde Ægyptens*, IV., 3, 1905.

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claimed by a certain Khay as his property. A lawsuit followed in which Khay produced false title deeds whereupon Nubnofret, the mother of Mes, appealed to the official registers, saying, " Let there be brought to me the registers from the Treasury and likewise from the Department of the Granary of Pharaoh." A Commission was sent by the Court to make extracts from the registers, but by means of falsified copies Khay gained his case, but was, however, nonsuited on appeal when the evidence of many neighbouring landowners was taken.

In later times, about 900 or 850 B.C., the register of the lands and springs in the Oasis of Dakhla is referred to in an inscription which tells of a lawsuit concerning the ownership of a spring; 19 years elapsed before a decision was obtained.*

Thus, the owner's name, the area of the property, its position and the tax due from it were regularly recorded, and, in the New Empire at least, duplicate registers were kept in the Treasury and the Royal Granary.

The same system of land registration continued down into Arab times as papyri dating from Græco-Roman sites show, and the system in the form in which it has survived has just been brought into accord with modern methods of measurement and computation. These early cadastres were records of the area of each holding, and included a description of its position as defined by the neighbouring properties, but cadastral maps, properly so-called, were not prepared so far as we know. Still holdings were carefully measured up with cord or rod, and the Chief Measurer of the property of the god Amen at Thebes was a temple official of high importance.

Unquestionably the great fertility of the Nile Valley, the density of its population rigidly confined between two vast expanses of desert and restricted to an area which has varied from about four to seven million acres, according as how much was marsh and waste land at the time, and especially the annual setting out of holdings on the flood plain as soon as the inundation was over, gave a special importance to careful measurement of the land, and the recording of each man's area and its quality.

In Babylon, too, where a fertile river valley supported an advanced civilization, land measurement was of great importance, and the clay tablets from Tello, on which the records were made, have preserved to us from the earliest times of its history, cadastral plans of properties, and much information of like character.

No map of landed property in ancient Egypt has come down to us, but on the tomb walls we meet with representations of land measurers at work. Their methods of land measurement are represented on the walls of the tomb of one Menna† at Thebes, a

* Spiegelberg, *Recueil de travaux, etc.*, 1899, p. 12.
† Borchardt, *Zeitschrift für Ægyptische Sprache*, 1905, p. 70.

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scribe of the fields and inspector of the boundary stones of Amon. The tomb, which is situated in that portion of the Theban burial ground known as Sheikh Abd el Qurna, has recently been cleared out by Mr. R. Mond. The scene depicted shows two chainmen measuring a field of corn with a long cord on which are knots or marks at intervals which seem to be about 4 or 5 cubits in length: each also carries a spare cord coiled up on his arm. Beside them walk three officials, who carry writing materials and who are accompanied by a small boy carrying writing materials and a bag in which are probably documents and plans referring to the property. An old man and two boys also accompany the surveyors, and a peasant brings a loaf of bread and a bunch of green corn.

Papyri from Tebtunis give a detailed description of certain small plots of land on the east side of Crocodilopolis Arsinoe (Medinet el Fayum) between the road round the town and a large canal. The dimensions are given in *schoenia*, and the plots are of the usual small size; some belong to private individuals, one belongs to the queen, another is recorded as common land, while a public road between the private property and a public canal is separately registered. The same conditions may be exactly paralleled round Medinet el Fayum to-day.

Without doubt the land measurers of this period were but continuing the procedure of earlier times in the methods which they employed. Lines were measured along the heads of the plots, the breadth of each field being recorded as well as its length; from this the areas of rectangular fields could be calculated. Frequently the lengths of all the sides were recorded and the area was then computed by obtaining the product of the means of the opposite sides whatever the angles of the figure might be. The part of the village lands in which the line starts is described and then the detail measurements are recorded.

The Roman land measurers* developed a most effective system which spread through the Empire, and in their work laid the foundation of many of the local surveys of Europe.

Thus it may be seen that wherever land is fertile or thickly populated land measurement of considerable elaboration and accuracy is early found to be a necessity. In all countries, whether settled or in course of development, land of all kinds and qualities will fall within the scope of a Cadastral Survey, and one class will shade into another by imperceptible graduations so that classification is at all times difficult. As examples of the way in which the demands made upon this class of surveying may vary we may take:—(*a*). Forest and grazing lands. (*b*). Lands partially cultivated. (*c*). Good agricultural land. (*d*). Town property.

* *Die Römischen Agrimensoren*, Dr. M. Cantor, Leipzig, 1875.

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Much land in Australia and other pastoral regions is of the first category and maps on scales as small as 1 : 126,720 will often meet all requirements.

The second class may be found plentifully in every country, especially in its more hilly districts, or in the low-lying unreclaimed parts such as river deltas. We may instance the Scottish Highlands, or the hill ranges of Cyprus, or the northern margin of the Nile delta, until its reclamation by means of the surplus water of the river ponded up by the Aswan Dam is an accomplished fact.

Fertile agricultural land has already been alluded to as having from the earliest times been measured and recorded with all the care and precision that its occupiers had at their command.

In each of such classes maps of a certain scale will show with sufficient accuracy the various holdings, and give such additional information as may be desired.

We may say that 1 : 25,000 to 1 : 100,000 for the first ; 1 : 5,000 to 1 : 10,000 for the second; 1 : 2,500 to 1 : 4,000 for the third; 1 : 250 to 1 : 1,000 for the fourth class will generally suffice.

A much higher accuracy of location will of course be required for the larger scales than the smaller, but in general it is more satisfactory as well as more convenient to extend the most accurate network of controlling triangulation over the whole area, filling in with more or less close networks of triangulation of lower orders according as more or fewer points will suffice for controlling the detail.

Wherever holdings are small and closely grouped together many additional points will be required, but if the main triangulation, of whatever order has been decided upon, has been completed over the whole area, it is a comparatively simple matter to prepare a local network of a lower order and a suitable density of points for any particular portion. In the same way so long as the control is of a sufficiently high order of precision, the scale of the map can be varied anywhere for town, or fertile area, or waste track without difficulty.

Where so high an accuracy is demanded over large areas, and where in one part holdings are small and in another they are large, the only means of effectively controlling such land measurements is to employ the best and most precise triangulation that time, means, local conditions and available staff will allow.

Triangulation of the First Order is no doubt the ideal control, wherein the triangular error is less than 1", but this is a counsel of perfection which can usually be attained only in fully settled regions where the population is fairly dense and the importance of an accurate Cadastral Survey is administratively recognized. In lands still in a more or less forward state of development, pressure is always exercised in favour of a survey of less efficiency which will be " good enough " for existing conditions ; and it must be admitted that there are probably in such regions many other administrative reforms,

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and projects of urgent importance to the community, so that to maintain that an efficient Cadastral Survey can only be executed on the basis of the most precise and complete geodetic triangulation is to demand what is in many cases unattainable at the time, and may prejudice unreasonably the whole project. Money, time, staff, and local conditions must all be given due weight in preparing a scheme for a Cadastral Survey, and here as in topographical work it may often be a sounder policy to push through a reasonably complete and efficient scheme so designed that revision may be effectively and economically undertaken at a later date, than to embark on an undertaking of higher precision which can advance but slowly at a time when the country urgently requires to proceed to the settlement of land revenue or the registration of real estate. Under such conditions three essential safeguards must be borne in mind as furnishing the guarantees for the permanent value of such work as is done, viz. :—

(1). Precise and permanent marking of points.
(2). Definition of the permissible limits of error in all the operations.
(3). Mathematical control of the whole work.

To these points I shall return later.

As a recent Royal Commission has reported against the compulsory registration of title to land in this country, we may dismiss from our consideration the special conditions which prevail here, and consider rather those which are met with in what we may term partially developed regions, such as are represented in the Crown Colonies and the Oversea Dominions.

From the East African Protectorate, the Gold Coast, Nigeria, Nyasaland, Sierra Leone, Uganda, British Honduras, Cyprus, Hong Kong, Jamaica, the Federated Malay States (Revenue Survey) and Trinidad, Cadastral Surveys or Land Surveys for the registration of property or the assessment of land tax are reported in Colonial Office Report (No. 775) for the year 1912–13, so that there is a large amount of this class of work in hand in regions where no complete triangulation or topographical survey of precision yet exists.

By means of " Invar " wires and tapes the measurement of bases has been greatly facilitated, and they may now be measured rapidly and with sufficient accuracy for use in any control triangulation which may be required. The error, co-efficient of expansion, and variation of length under different tensions having been furnished with the wires from an authoritative institution such as the National Physical Laboratory, one wire should be kept for measuring short-control lengths in the neighbourhood of the triangulation bases so that the wires employed in the latter may be verified before and after the measurement of the base. Since with apparatus of this character

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base measurement has been so much simplified, it is frequently advantageous to increase the number of bases measured, and reduce the extent of triangulation network between each. In this way the accumulation of errors in the triangulation is controlled, and the network between adjoining bases can be computed, adjusted, and used for controlling the detail measurement at the earliest possible time. In Egypt where international agreement had imposed a limit of ten years for the completion of the Cadastral Survey, the work could only be accomplished by measuring frequent bases, and eight in all were used in surveying an area of about seven and a-half millions of acres of land.

On these bases is built up the best and most accurate triangulation that the means available and the conditions of work will allow. Triangulation of the First Order will rarely be practicable in the first instance, but Second Order Triangulation, in which the angular error of any triangle may not exceed 5", should be employed and should be kept at as high a standard as possible. Since the length of the sides will be of from 10 to 20 miles this Second Order network will have to be filled in by triangulation of the Third Order in which the angular error of any triangle will not exceed 15", and in both these orders of triangulation all angles of the triangles should be observed. 8-in. theodolites should be used for the Second Order and 6-in. instruments should be used for the Third Order, both being furnished with microscopes for reading the divided circles.

Average Length of Sides of Triangles in Kilometres.

Order.	Prussia.	Saxony.	Würtemberg.	Austria.	Bavaria.	France.	Egypt.
I.... ...	20 and over.	20 and over.	10–75	15–30	15–40	20–40	20–50
II. ...	10–20	10–20	4–30	9–15	5–15	15	10–20
III. ...	3–10	2–5	0·7–5	3–9	2–5	*	3–5
IV. ...	under 3	0·5–2	—	—	0·5–2	—	under 3

* Not yet up to the standard needed for cadastral plans. (See Reports of the Extraparliamentary Commission).

In this manner a network of points will be provided the position of each of which is accurately known, and all these points should be marked in a permanent manner so that the exact point of reference can be subsequently determined without doubt. The expenditure on this head is too often insufficient, and no item is more worth dealing with generously; examples are readily found, and in Egypt not a single point could be found in 1898 of all the points fixed

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by the Cadastral Survey of 1878—1888 on which nearly half a million of money had been spent, and the whole work had to be redone. A careful record kept from the beginning of a survey of all triangulation points with the exact descriptions and a note of the degree of accuracy of each finally accepted position is an essential provision of every survey, but especially in cadastral work.

Where holdings are small and time is available it frequently happens that a triangulation of the Fourth Order in which the sides are from 0·5 to 2 miles gives a valuable control to the traverse and to the subsequent chaining of the detail measurement.

But even if the holdings are of moderate size more points than those furnished by triangulation of the Fourth Order are required, and these may be provided either by direct chaining or by a system of theodolite traverses. In the Ordnance Survey an elaborate system of chained triangles was used, but this is not suited to all conditions; straight lines are rarely in agreement with the property boundaries, and moreover accurate chaining over long distances or where detail is close and intricate needs much experience. Theodolite traversing is usually practicable and possesses the advantage that it can follow conveniently the most irregular boundaries; at each change of direction is a point the co-ordinates of which can be computed and corrected to bring them into adjustment with the controlling triangulation and by such computation a very effective control of the traverses is provided. At the time of survey it very frequently occurs that land is to be divided into groups of holdings such that, the land being of one quality, a single rate of tax can be fixed for the group, and in this way the revenue work is facilitated. In this case traverses can be carried round such areas with little trouble by suitably arranging the primary and secondary traverses and the traverse points furnish boundary marks for such fiscal units. Traversing with the theodolite is most advantageous where the intervening distances are long, but these must be limited by the rate at which errors of measurement increase. In practice the distance between adjacent traverse points is usually from 300 to 500 metres, and each distance is measured twice with a steel chain or preferably a steel band, and the mean error of such double measurement need not under moderately favourable conditions exceed 1 in 1,500. Each primary traverse should run from one triangulation point as directly as possible to the next triangulation point, and the closing errors both of direction and of the x and y co-ordinates have to be distributed over the traverse and the corrected positions of the traverse points thus determined. The number of these traverse points will naturally vary with the size of the holdings, the unevenness of the ground and the number of the obstacles on it. As an example the practice of the Prussian cadastre may be quoted, in

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which 14 to 40 points per square kilometre, or about 35 to 105 per square mile according to the size of the holdings are employed.*

In Austria it is laid down that the number should be from 20 to 50 points per square kilometre, and in Bavaria from 20 to 60 are provided. In Egypt where the country is very easy for measurement, since the land is flat, and no woods or other obstacles occur, 14—18 is the usual number per square kilometre, but this would probably be increased in the case of registration of title being introduced. The number laid down for European surveys includes the increased number required in villages where house property has to be registered; but in Egypt traversing has not yet been done within the area occupied by the buildings of the village so that comparison should be with the open country only. The lengths of polygon sides are usually measured twice, either with 20-metre steel bands or 5-metre wooden rods, in Europe the latter being often preferred on rough ground; the angles are usually measured with 5-in. theodolites, readings being taken in both positions of the telescope.

Thus the traverse points mark the known positions on which all the detailed measurement depends, and the previous triangulation has for its object the control of the accuracy of many thousands of such traverse points which are permanently marked for future reference. In view of the very large numbers required, no elaborate form of mark is for the most part employed. In agricultural land in Europe a short length of earthenware drain-pipe sunk vertically in the ground with its top about 18 in. below the surface is often used; in towns, less destructible forms are necessary, and the mark is then made of metal and is set in a cast-iron box in the curb of the side-walk, or a bolt set flush with the surface of the pavement. In any case the permanency of at least a large proportion of these marks and facility in finding them when they are required to record alterations or to make periodical revisions are essentials.

It is necessary at an early stage to lay down what magnitude of error is permissible in the measurement of the lines joining these traverse points in order that the fieldwork may be controlled and an equal standard of accuracy be attained throughout the whole of the area under survey.

The discrepancies which are admitted between the two measurements of the side of a traverse or a chain-line, or between the distance apart of two points as determined by a traverse and by the triangulation, vary slightly in different countries; the formulæ which are used to express these permissible errors (d) in length are given in

* *Anweisung (IX.) für die trigonometrischen und polygonometrischen Arbeiten des Grundsteuerkatasters.* Berlin, 1903.

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the following table which is taken from the regulations of the different surveys* :—

Country.	Linear Closure Error of Traverse.	Discrepancy between Two Measurements of any Line.
Würtemberg ...	I. $d=0{\cdot}010\sqrt{L}+0{\cdot}0005\ L$ II. $d=0{\cdot}015\sqrt{L}+0{\cdot}0006\ L$ III. $d=0{\cdot}020\sqrt{L}+0{\cdot}0007\ L$	The same.
Prussia...	I. $d=0{\cdot}01\sqrt{}\ (4\,[L]+0{\cdot}005\,[L^2])$ II. $d=0{\cdot}01\sqrt{}\ (6\,[L]+0{\cdot}0075\,[L^2])$ III. $d=0{\cdot}01\sqrt{}\ (8\,[L]+0{\cdot}01\,[L^2])$	$d=0{\cdot}01\ \sqrt{}\ (4\ L+0{\cdot}005\ L^2)$ $d=0{\cdot}01\ \sqrt{}\ (6\ L+0{\cdot}0075\ L^2)$ $d=0{\cdot}01\ \sqrt{}\ (8\ L+0{\cdot}01\ L^2)$
Saxony...	I. $d=0{\cdot}000654$ [L] for steel band II. $d=0{\cdot}000951$ [L] ,, ,, ,, $d=0{\cdot}0002133$ [L] for rods	The same.
Austria...	I. $d=$ as for II. but $-20\ \%$ II. $d=0{\cdot}0006\ L+0{\cdot}02\sqrt{L}$ III. $d=$ as for II. but $+20\ \%$	The same.
Egypt ...	(As for Prussia).	—
France...	$d=0{\cdot}10+0{\cdot}012\sqrt{L}$	I. $d=0{\cdot}008\ \sqrt{L}$ have been proposed. II. $d=0{\cdot}0012\ \sqrt{L}$,, ,, III. $d=0{\cdot}0016\ \sqrt{L}$,, ,,
Italy† ...	I. $d=0{\cdot}015\ \sqrt{L}+0{\cdot}0008\ \sqrt{L}+0{\cdot}1\ \sqrt{n-1}$ II. $d=0{\cdot}020\ \sqrt{L}+0{\cdot}0008\ \sqrt{L}+0{\cdot}1\ \sqrt{n-1}$ III. $d=0{\cdot}025\ \sqrt{L}+0{\cdot}0008\ \sqrt{L}+0{\cdot}1\ \sqrt{n-1}$	I. $d=0{\cdot}015\ \sqrt{L}+0{\cdot}0008\ \sqrt{4}$ II. $d=0{\cdot}020\ \sqrt{L}+0{\cdot}0008\ \sqrt{L}$ III. $d=0{\cdot}025\ \sqrt{4}+0{\cdot}0008\ \sqrt{L}$

These permissible errors may be best exhibited by taking a few lengths of polygons and comparing the errors (in metres) which the different surveys would admit :—

Sum of Sides.	Würtemberg.			Prussia.			Saxony.			Austria.		
							With Steel Band.		With Bars.			
	I.	II.	III.	I.	II.	III.	I.	II.		I.	II.	III.
200 metres...	0·24	0·33	0·42	0·32	0·39	0·45	0·13	0·19	0·04	0·3	0·4	0·5
500 ,, ...	0·47	0·64	0·80	0·57	0·70	0·81	0·33	0·48	0·11	0·6	0·75	0·9
1,000 ,, ...	0·82	1·07	1·32	0·95	1·16	1·34	0·65	0·95	0·21	1·0	1·23	1·48
1,500 ,, ...	1·14	1·48	1·82	1·32	1·61	1·86	0·98	1 43	0·32	1·34	1·67	2·0

* I., II. and III. refer to easy, moderate and difficult ground.

n = the number of points in the traverse, including both the first and the last.

† *Istruzione sulle Poligonazioni*, 1889.

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In Egypt the same limits were employed as in Prussia and this accuracy was attained by the Egyptian surveyors without serious difficulty.

In closing on a triangulation point the angular error which has been accumulated in the traverse is ascertained and this may not exceed a certain amount, which is laid down in every survey as the following table shows :—

Permissible Difference in Closure of Traverses.

Number of Angles.	Prussia. Würtemberg.	Saxony.		Austria.	Egypt.*
		Steel Band.	Rods.		
4	3′ 0″	2′ 0″	0′ 46″	2′ 30″	3′ 0″
8	4′ 12″	2′ 50″	1′ 05″	3′ 32″	4′ 12″
12	5′ 12″	3′ 28″	1′ 20″	4′ 20″	5′ 12″
15	5′ 48″	3′ 52″	1′ 29″	4′ 50″	5′ 48″
Formula ...	1′ 30 $\sqrt{n}$	60″ $\sqrt{n}$	23″ $\sqrt{n}$	75″ $\sqrt{n}$	1′ 30″ $\sqrt{n}$

* For town plans on 1 : 1,000 the formula is 45″$\sqrt{n}$.

In all cases where a Cadastral Survey is in progress or is contemplated, such as the Crown Colonies or in outlying portions of the Oversea Dominions, a ready-trained staff will not probably be available in the first instance, but will have to be organized. This must depend largely on the *personnel* which is available, and in the Crown Colonies the majority will probably be drawn from the inhabitants of the Colony and may have but an elementary knowledge of surveying and the branches of technical knowledge which are most required. Here the problem is to divide the work into successive simple stages, each of which can be efficiently carried out by the staff available, and at the same time to maintain a supervision and control sufficiently close and stringent to ensure the necessary standard of accuracy being maintained.

In the Dominions a much higher grade of surveyor will be available, so that the problem is different, and here it will be important to economize the surveyor's time and energy to the utmost in order that his skill and knowledge may be available for the more technical parts of his work, and purely routine operations may be rendered as speedy and as little irksome as possible. Whether it is necessary to employ an imperfectly trained and educated native staff, or to get the largest out-turn from a skilled staff comparatively few in numbers, it is

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universally recognized in these days that work must be planned and staff organized to this end. Cadastral surveying involves a vast number of simple computations in order to obtain the co-ordinates of the thousands of traverse points, and of products in determining the area of holdings; these thousands of points have to be accurately plotted on the field sheets from the co-ordinates so determined, and long lists of areas have to be totalled and verified in the land registers. All this can be done rapidly and accurately by a native staff of very small educational acquirements if the work is arranged so as to make use of modern mechanical appliances for computing and plotting. Multiplying machines, of which there are now many reliable patterns, enable the computation of L sin θ and L cos θ (where L is the length of the side in a traverse and θ its azimuth angle) to be carried out rapidly in combination with a suitable table of natural sines and cosines. These machines are also indispensable for computing areas, while adding machines greatly facilitate the totalling of plot areas, etc. The advantage of such machines is not merely that they enable unskilled computers to be employed, but also that the mental effort involved is much less than the using tables of logarithms or even traverse tables, so that the work can be carried on longer without prejudice to its accuracy.

In plotting the numerous determined points from their co-ordinates an instrument known as the co-ordinatograph* is of the utmost value. By its aid unskilled workers can after a few days' practice plot points to an accuracy of 0·1 m.m. at an average rate of from 30 to 40 points an hour.

Similarly, a skilled staff will be greatly assisted by the same aids in performing the more laborious part of their work, and at the present time in some surveys all geodetic computations are so arranged as to be conveniently made with the aid of such computating machines. But in order to gain the fullest advantage from such methods suitable arrangements must be made for their direction and control; and in all surveys of this nature, where the accuracy of areas and of boundaries is of special importance, there is great advantage in so arranging the work that all the computations of triangulation and traverse observations, as well as all projecting of map-sheets, and the plotting of the computed positions of points, are done in a special office in which the computing staff work under the superintendence of a qualified mathematician. In this office he receives each piece of observational work and treats it as a mathematical problem; here it is examined by computation and either rejected as exceeding, or passed as falling within, the permissible limits of error. Moreover as all the neighbouring observations have passed or will shortly pass through his hands, he can usually indicate at once which piece of work should be repeated to

* Made by Coradi, Zürich.

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locate an error, such as may for instance have thrown out a portion of the triangulation network.

Administrators not infrequently object to the staff being employed in office during the working season, but as a general rule much time, money, and work is economized by keeping the chief of the computing office at his special work. He has much to get ready in order to deal quickly with the heavy accumulations of the material which is continually being received from the observers in the field, and the standard of accuracy which can be maintained is largely dependent on the efficiency of his control, and the thoroughness of his examination. Such an office if properly administered and efficiently directed is the best safeguard against fudged observations and slovenly measurement, since it deals with the results obtained quite independently of the field parties; further, much valuable advice is obtainable from such investigations as to whether any portion of the work is carried on at a standard of accuracy which under the circumstances is uneconomical, or whether increased accuracy at any point would be worth the additional outlay involved. No Director of Survey who has had the assistance of a skilled mathematician in charge of his computing office would ever willingly dispense with such an important aid in advancing the economy and accuracy of the work.

When all traverse points have been marked in the ground, the chain survey of the holdings becomes a simple matter, but even if the measurements are entered up in a chain book, a plotted field sheet on which the traverse points are shown correctly plotted, so that between them the detail can be filled in as it is measured up, and on which all plot boundaries are drawn in, is a necessity. Offsets should be kept of moderate length, and in Prussia those of over 10 metres in length must be taken with the aid of a cross staff, and preferably with an optical one; if longer than 40 metres, a tie line must be measured; those by which boundaries are fixed may not be longer than 10 metres. In Saxony, offsets to boundaries may be 10 metres long; any which are over 15 metres in length must have a tie line; and none, though taken with a cross staff, may be longer than 50 metres in level country, or 25 metres in uneven parts. In Austria the cross staff is to be used for offsets to well-defined points over 4 metres, to less definite points over 10 metres, and the limit of length for them is 50 metres on level ground and 25 metres on rough ground. In the Egyptian Survey, the limit for these is 20 metres, and the cross staff is always used, but hitherto it has not been an optical one.

Frequent reference to the owners of property must be made in the course of the work, and the field sheet is a great assistance in this. The amount of work which this part of the survey involves will vary greatly with the shape and arrangement of the holdings. Those which are approximately rectangular and

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which lie parallel to one another present little difficulty, though cases occur where such holdings are but 3 or 4 yards wide and as much as 800 or 1,000 yards in length. Such exceptional holdings are to be found in the rainless irrigated land of Egypt where it is essential that every holding should abut on a supply canal, or in the plain of Northern Prussia where free access to a drainage channel is equally important. Irregularly-shaped plots and those which are scattered through poor and uncultivated land require more work than a fertile tract. But usually the areas of holdings are also to be computed from the field measurements, so that sufficient must be made to enable this to be done unless graphical computation of areas is admitted. These field sheets, or "Handskizze" as they are termed in Germany, must therefore contain full indications of these measurements so that the area computations can be accurately made from them. These field sheets either in the form that they are made out in the field, or fair copies in which all measured dimensions are plotted, become the documents which are preserved in the Cadastral Office for future reference, and from which cadastral maps are published if publication is a part of the scheme. Such dimensioned field sheets differ from the 1 : 2,500 sheets of the Ordnance Survey, since, besides being drawn to a scale, they also contain all the measured dimensions and offsets so that the whole of the information which defines the location of a holding, its shape, and its area, is given thereon, and thus furnishes the evidence which the registration courts demand.

With such dimensioned plans and a system of traverse points permanently marked on the ground, transfers of property, division of holdings, rectification of boundaries, expropriation of land and all the many operations which are continually needed in connection with the land of every civilized community may be made with certainty and accuracy whether they are situated in their open cultivated lands, or in the crowded streets of their cities.

The next operation after the location and measurement of all the holdings is the determination of the area of each.

The areas of plots are usually taken out firstly by mensuration and then for the second time graphically. In the Cadastral Survey of Saxony, the disc planimeters of Coradi of Zürich are used for taking out the areas of plots on the scale of 1 : 1,000, two independent determinations being made. It is maintained that the results of long and careful investigations show conclusively that the difference between two determinations of area with these instruments, when shrinkage of the map-sheet has been allowed for, does not exceed that occurring between two computations of the same if these are made in different ways ; *e.g.* firstly from the measured dimensions, and secondly from the co-ordinates of the angles of the plot.

The next control is to determine the area of groups of plots up to about 30 in number with the planimeter, and to compare the result with the sum of the plot areas.

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In the Prussian Survey not more than 60 hectares may be taken on the scale $\frac{1}{4000}$; 20 on a scale of $\frac{1}{2000}$; 5 on a scale of $\frac{1}{1000}$; and 1 hectare on a scale of $\frac{1}{500}$.

The final control is the comparison of the area of projected map-sheet with the sum of the portions which it comprises.

The permissible difference (a) between the computed area and the graphical control is 0·01 ($60\,A \times 0{\cdot}02\,A^2$), for the scale 1 : 2,000 where A is the area of the plot. In Austria the computation of areas is carried to a square decimetre for parts of plots in towns, and to a square metre in ordinary plots. The control groups of plots are :—

30—50 hectares on the scale 1 : 2,500,
8—12 ,, ,, ,, 1 : 1,250,

and generally they occupy about 5 to 8 square decimetres on the map. Such groups are usually taken to coincide with polygon sections.

The formulæ used for determining the permissible differences in area between two independent determinations are :—

Prussia ... $a = 0{\cdot}01\sqrt{(60A + 0{\cdot}02A^2)}$ a and A being in units of 100 square metres.

Würtemberg $\begin{cases} a = 0{\cdot}25\sqrt{A} + 0{\cdot}00075A \\ a = 0{\cdot}5\sqrt{A} + 0{\cdot}00075A \\ a = 0{\cdot}75\sqrt{A} + 0{\cdot}00075A \end{cases}$ Under different conditions.

Austria ... $a = 0{\cdot}0001A + 0{\cdot}5\sqrt{A}$.

The formula for Austria is that used for the scale of 1 : 2,500; those for other scales are :—

For scales 1 : 1,250 and 1 : 1,440 $a = 0{\cdot}001A + 0{\cdot}25\sqrt{A}$.
,, ,, 1 : 625 and 1 : 720 $a = 0{\cdot}001A + 0{\cdot}125\sqrt{A}$.
,, scale 1 : 2,000 ... ... $a = 0{\cdot}001A + 0{\cdot}4\sqrt{A}$.
,, ,, 1 : 1,000 ... ... $a = 0{\cdot}001A + 0{\cdot}2\sqrt{A}$.

When the areas of plots are taken out graphically by two independent operations, as in Egypt, the results can be checked (1) by determining planimetrically or by computation of the traverses the area of a group of plots amounting to about 80—100 acres, and (2) by the area contained in each projected map-sheet.

The planimeter is too well known an instrument to require description here, but it may be stated that the special form of the polar planimeter known as the compensation planimeter* has been found very satisfactory. It admits of the movable arm being used on both sides of the polar arm, which has the advantage of giving a compensation for any non-parallelism between the axis of the roller and the movable arm, for it can be shown theoretically that, if the required area is measured once with the pole on the right and once with it on the left, the error due to this non-parallelism changes sign and so

* Constructed by Coradi of Zürich, and others.

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disappears from the mean of the two measurements. To take full advantage of this compensation, the planimeter must be disposed as symmetrically as possible with respect to the area to be measured, in the two positions.

Each instrument is checked every day on which it is used, with the special radius provided which enables accurately known areas to be measured, and, if necessary, is properly adjusted. The regular use of the radius for checking the adjustment of the planimeter is important when unskilled computers have to be employed, for it gives an inspector a measure of the instrumental error, and so enables him to detect readily indifferent work on the part of the computer. If, using the radius, the average difference between the results with the pole to the right and to the left is, say, 1 per thousand, an examination of the pairs of results obtained for the areas of holdings, will show whether the computer is adding materially to this difference by following incorrectly the boundaries of the figure which he has measured.

So much on the part of the State, but it should be incumbent on every landowner to mark the boundaries of his property in such a manner as to indicate them precisely. It is usually laid down that marks of a suitable character shall be placed on the boundary of each property so that the straight line joining them shall determine the holding. This general marking of property is a large and expensive operation, and in some cases where it has been introduced, and was not previously the general custom, the State has borne the first cost of carrying it out.

When the measurements are complete and have been checked and passed the fair map is drawn from the field sheets and is kept as a document to accompany the Land Registry. In some countries, *e.g.* Austria, Würtemberg, Bavaria, India, Egypt, etc., these land maps are printed; in others, *e.g.* Prussia, France, the Canton of Geneva, etc., the originals are kept and tracings of any portion are supplied as required. If it should be decided to print the maps then this should be done at the headquarters of the survey, for a poorly-printed map which is available at once is far more useful than a well-executed one which is received some months later, by which time a host of changes due to sales, transfers, etc., will have accumulated.

Besides the foregoing technical matters there are others which cannot be learnt beforehand, but which must be studied on the spot, and the necessary modification then made in the procedure which is adopted. Some of these are primarily physical and are connected with the local conditions of the country, others are social and relate to the customs of the inhabitants, but both classes require local knowledge on the part of the Director of the Survey.

Where parts of the country are but partially reclaimed large tracts may need little more work than traverse lines around their borders, but provision must be made for extending work over these

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tracts at any time that their improvement is taken in hand. The relief of the country may be so broken up that continuous cultivation is impracticable and isolated patches alone occur, as in "The Hummocks" in the southern foothills of the northern hill range of Cyprus. Here traverse points must be numerous to assist the detail.

Where the climate and soil are favourable cultivation may be carried up the steepest hillside by terraced holdings, as in the Rhine Valley, in many parts of Italy, in the southern hill range of Cyprus, etc., and here the steepness of the slopes offer considerable difficulties to the surveyor; in warm climates such situations are often highly fertile and the accuracy necessary is as high as on alluvial plains. In some countries trees are owned separately from the land, *e.g.* fruit trees in Tyrol, date palms in Egypt, olive and fig trees in Cyprus, and though these are not shown in the maps, they are recorded by number and reference to the plot in which they stand.

Social customs are naturally more difficult to deal with than physical conditions, for the land surveyor is always regarded with suspicion, and often with disapproval.

Where a cadastre is being instituted for the first time to replace an old and perhaps inaccurate system, any reduction of a landowner's taxable area in course of its remeasurement and recomputation of its size by accurate methods, is regarded as a fraud upon the owner who has thereby lost some of his property. Thus the Egyptian methods of computation derived unchanged from the earliest historic times, and which are still in use in the villages, tended to show the area of a plot as greater than it really was. Consequently the correct surveying of property produced thousands of complaints that land had been deducted from a property whereas in fact the alleged deficient area had never existed. In Cyprus on the other hand the popular unit of area is slightly larger than the legal unit, so that each landowner's property seems to have been increased and complaints of incorrect area are comparatively rare.

Religious differences occasionally give rise to difficulties as for instance in parts of Egypt where Moslem and Coptic landowners dwell in the same village and their holdings are intermixed. In the past separate land registers had been compiled for those of each religion, and at first there was some opposition to all holdings being recorded in a single register.

There is no royal road to success in Cadastral Surveying, but the local conditions must be carefully studied, plans must be fully mapped out so that the work is started on a full and definite procedure; the area undertaken in the first instance may be as small as staff, funds, and experience demand, but whatever it be the work should be planned and carried out thoroughly, the permissible errors not being exceeded, marks being fixed and recorded, and all done with a view to the ready and effective revision of any portion at any subsequent time.

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SEA ENCROACHMENT, FORT RICASOLI, MALTA.

By CAPT. C. W. BIGGS, R.E.

FORT RICASOLI is situated on a narrow peninsula of rock approximately 50 ft. to 60 ft. high, and about half-way along it there is a distinct fault in the rock which goes apparently right across from the sea to the harbour side.

On the harbour side there are a number of caves at water level which are known to run for some considerable distance into the rock, and there are fissures in the rock above. No heavy seas are, however, experienced on this side, so that no real damage has been done. On the seaward side the effect of the sea on the fault has been considerable. The trace of the bastion walls, built by the Knights of Malta in about 1670, shows that even at that date an inlet on the line of the fault existed. This inlet faces north-east, and is thus exposed to the worst seas that come up with a "gregale," and the fault on this side is from 15 ft. to 20 ft. wide, filled with loose rock and clay formation. It can be clearly seen in the photographs.

The winter storms have gradually eaten into the fault, washing out the loose material and breaking off pieces of the rock on either side, and burrowed a regular tunnel under the parade ground. In about 1888, according to local information, a small hole about the size of a penny at first appeared in the parade ground about 100 ft. behind the bastion wall, and during a "gregale" a regular jet of water used to spout up through it. This, and the shock of the waves pouring into the tunnel, had the effect of enlarging this hole in the parade ground, until it is now some 30 ft. in diameter at the top and considerably more below. A fence was erected round it in 1890 or 1891, and it is known as "the Cave."

The tunnel which is now about 10 ft. to 12 ft. wide and 7 ft. high was walled up at the entrance and the cave was filled up two or three times, but the wall was broken down and the filling, with the exception of some three or four old 25-ton guns, was washed out. The entrance to the tunnel and the remains of the wall can be seen in the photographs, which also show the fence on the parade ground round the cave.

As the inlet became deeper it became more funnel shaped, so that the force of the waves breaking at its head increased, and the latter was finally so undercut that, during a storm on the night of the 31st March, 1906, a large portion of the parapet between the points AA (see *Plate*) fell into the sea. The only steps then taken were to erect a fence round the gap.

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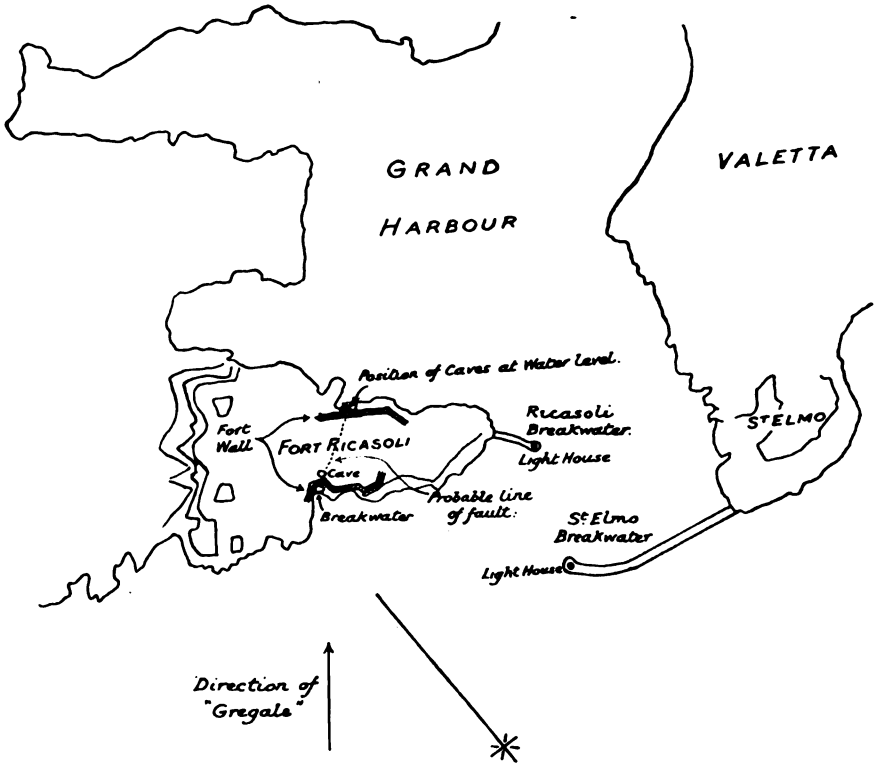
In 1908, one of the worst " gregales " experienced for a long time raged and further heavy falls of the cliff occurred. This " gregale," incidentally, also washed away practically all the heavy piles and staging, cranes, etc., in use by Messrs. Pearson on the St. Elmo Breakwater, then in course of construction, and the Ricasoli defence lights were run for several nights to assist Messrs. Pearson's men.



The safety of the rear portion of the Ricasoli Recreation Room and Billiard Room was now threatened ; the rock face above the tunnel was so undercut that the waves broke right into the cavity so formed sending solid sheets of spray flying right over the parade ground, and the shock was so great that liquid was spilt out of glasses standing in the Billiard Room. The question of stopping any further encroachment by the sea was therefore taken up by the C.R.E.

One of the first proposals was to put up a reinforced concrete wall, taken down to solid rock level and well keyed on either side to the rock on the line BB (see *Plate*), and to fill up behind with stone. The estimated cost of this was £1,200 to £1,600. A detailed survey was carried out and a diver from the Dockyard employed excavating on the proposed site on the line of the fault ; no solid rock was found, which showed that the fault went down vertically for some considerable distance.

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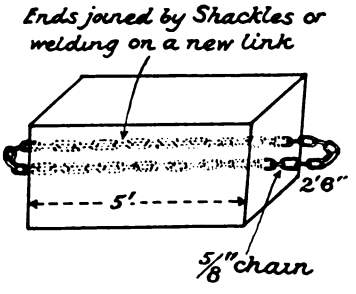
Messrs. Pearson's representative in Malta was asked to give his opinion on this proposal; it was to the effect that any wall erected would have to be at least as strong as the main breakwater of the harbour and would cost £10,000, the difficulty of providing a solid foundation being a serious item as nothing of this nature existed at a reasonable depth.

He recommended that a sort of breakwater should be made across the mouth of the inlet, by getting three large lighters, placing them in position (see *Plate*) raising their bulwarks and filling them with reinforced concrete till they sank, and in this way forming three large artificial rocks of about 900 tons each. The estimate for this was £4,000.

A third proposal was made by the C.R.E. viz., to make a breakwater of a number of small blocks 5 ft.×4 ft.×4 ft. or about 5 tons each, such as used in the Colombo Breakwater and in one at Osaka. The advantage of this proposal was that it could be carried out with local resources and added to as required.

This last proposal was approved by the War Office, and information was supplied of an Admiralty breakwater at Alderney which was formed of blocks, 5 ft. cube, chained together and piled in a rough mound. Details of the chain used were unfortunately not obtainable.

It was decided to make the blocks on the bastion just above the site chosen for the breakwater and then lower them into position. The blocks were to be of 6 to 1 concrete with the chain fixed through the centre, and were to set for two months before being moved. As the work was urgent and could not start until the chain was to hand, the latter had to be obtained locally, and after a strenuous hunt over the island, a quantity of good second-hand chain at a reasonable price was obtained. Some 80 blocks 5 ft.×4 ft.× 4 ft. weighing about 5 tons each were made during January and February, 1910, at C (see *Plate*) and had lengths of chain fixed through their centres. 1-in. stud link chain in 10-ft. lengths was used for 30 blocks; the other 50 blocks had 20-ft. lengths of $\frac{5}{8}$-in. close link chain (looped).



During these same months, a stone retaining wall founded on the solid rock, with a 4 ft.×3 ft. concrete foundation, was built

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round the top of the gap about 10 ft. back from the edge, and the iron fence was refixed on top of it. Where this wall crossed the fault, the concrete base was reinforced for a length of about 30 ft. with small iron rails.

In order to reduce the weight on the overhanging edge, the ends of the parapet walls were taken down for a length of about 5 ft. and practically all the loose earth (average depth about 3 ft.) in front of the new retaining wall was removed and thrown into the sea.

The cost of the work in 1909–10 was £502.

The blocks were lowered into position and the chains shackled together in April and May, 1910. A cable was stretched across between the bastion walls, over the site of the breakwater, and the blocks run out along this and lowered into position ; the shackling being done by divers. On the left of the gap some large rocks formed, to a certain extent, a sort of natural breakwater, and amongst these the blocks were laid anyhow. Across the rest of the gap, they were laid in a 3.2.1 formation vertically, and the chains shackled together both vertically and horizontally. Strong seas were experienced in July, 1910, and the whole breakwater settled down : several blocks out of the upper row were however removed altogether, and a weak place appeared in the centre. Extra blocks were made in position during September, to strengthen this.

Total cost of work in 1910–11, £450.

During the winter of 1910–11, fairly heavy seas were experienced and the top layer of blocks disappeared below sea level as time went on. The remainder however prevented any waves from breaking against the undercut back wall and doing any further damage.

When the breakwater could be closely inspected from a boat in May, 1911, it was found that a large number of blocks had been washed out to the front, chiefly from the top two rows in the centre, and that the rest of the blocks had sunk a foot or so into the sand and taken a bearing in the soft bottom. Further work was imperative, and it was proposed to make 20 more blocks of a much larger size in position on top of the existing blocks and chain them together as before, but with much stronger chain.

On reference being made to the War Office some very important suggestions were made ; the main points being that the blocks originally used were too small and blocks up to 40 tons should be used, any concave surfaces or re-entering angles in the face should be avoided ; also that the blocks should be backed with a bank of large stones to counteract the effect of the backwash. As the entrance to the inlet was narrow and restricted by sunken rocks, it was decided that the blocks could not be made elsewhere, allowed to set, and then brought to the site or launched off lighters, and so the original proposal to make the blocks in position was adopted.

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Access to the breakwater was got by descending into the cave and going out through the tunnel, but as the existing blocks were now all below sea level, it was necessary to build up a temporary platform at about sea level, on which to make the new blocks. Advantage was taken of the necessity to take down a large portion of an old bastion wall outside Fort Ricasoli which was in a dangerous state, and the material from this, mainly large stones, was brought into the fort, a bay of fencing removed, and the stuff dumped down behind the breakwater. This work took the whole of August (cost £74) so that the making of the blocks did not start till September, which, as experience showed, was rather too late in the year.

The work was carried out by direct labour. A platform of the large stones and empty cement barrels, filled with rough concrete, was constructed on the top of the existing blocks. The first of the new blocks made were 15 tons each, and as soon as they had set for three or four days they were launched off the platform to the front by means of jacks, thus adding to the depth (front and rear) of the breakwater. As experience was gained the blocks were made larger and the last ones were 10 ft. × 10 ft. × 6 ft. or 37 tons each. The work was constantly interfered with by rough weather, which not only washed away the temporary platform but broke up some of the blocks which had not had sufficient time to set.

The numbers of blocks made were as under :—

6 of 10 tons each, of which 4 were launched to the front and 1 destroyed.
9 of 15 tons each, of which 7 were launched to the front and 1 destroyed.
2 of 18 tons each, of which 1 was destroyed.
3 of 22 tons each, of which 2 were launched to the front and 1 destroyed.
6 of 37 tons each, of which 1 was launched to the front and 2 destroyed.

These were chained together by means of $\frac{3}{4}$-in. and $\frac{7}{8}$-in. chain, obtained from the dockyard at a nominal cost and placed through the blocks during construction, and by the shackles left over from the previous year.

In addition, an experiment was tried with a lighter ; an old one was bought for £16 10s. (including anchor and chain) and anchored close in front of the centre of the breakwater. It would have held from 90 to 100 tons, but most unfortunately the sea got up soon after the work of filling it was started and although work was carried on for two nights up to 12 m.n. it was sunk when only about half full. The restricted conditions under which the work was carried on made it much slower than was anticipated, and the rough sea at the very beginning of September was unusual. Even though only

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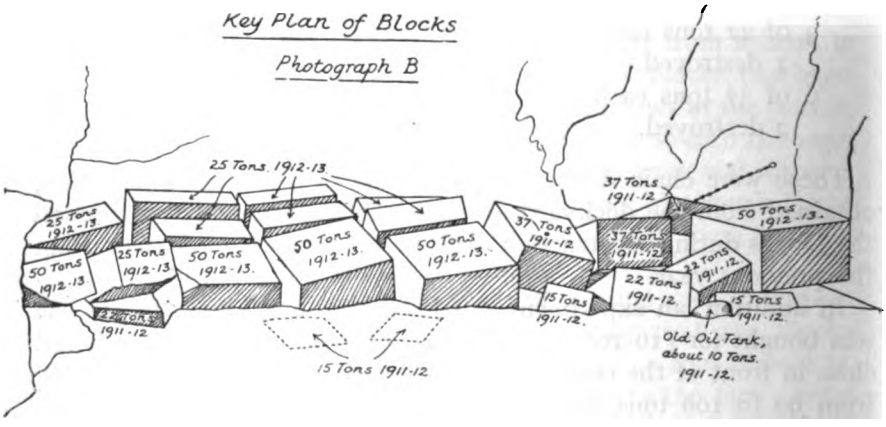
half full there is no doubt that this large block in front of the breakwater has helped to prevent the smaller ones from being washed out.

The winter seas, as was expected, washed away the temporary platform and all the blocks settled down. The result was however quite satisfactory, as on the left, where the large rocks under water were, a really substantial breakwater had been formed extending about half-way across, and on the right the blocks had got well settled in position. The centre however had suffered rather severely. All the blocks that were moved had been moved in towards the cave and not outwards as before, and, in addition, all the small stuff used in the temporary platform had been piled up into a bank at the mouth of the cave, so that the sea now was helping to defeat itself.

Cost of the work this year, 1911–1912, was £400.

In 1912–1913 the work done was practically a continuation of the previous year's, only the blocks made were of 50 tons each, viz., 12 ft. × 12 ft. × 6 ft., and were left when made. Each one was completed in a day, and is about the largest which can be made on this site without resorting to all-night work and consequently double working parties. Five of these 50-ton blocks were made, three in the centre and one in each angle at the side, and as a backing six 25-ton blocks were made later on behind those in the centre. Rough weather, however, was experienced soon after the work was completed, and two of the 25-ton blocks had not set properly and were broken up. In spite of its backing the centre 50-ton block was forced back some 10 ft. to 12 ft.

Cost this year, £185.



The accompanying photographs A, B and D show the work as completed in September, 1912, and C shows its condition in April, 1913. It will be noticed that even in September the temporary platform had been slightly washed away and that the centre blocks were settling down. The big block on the left-hand side (right in

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SEA ENCROACHMENT, FORT RICASOLI, MALTA.

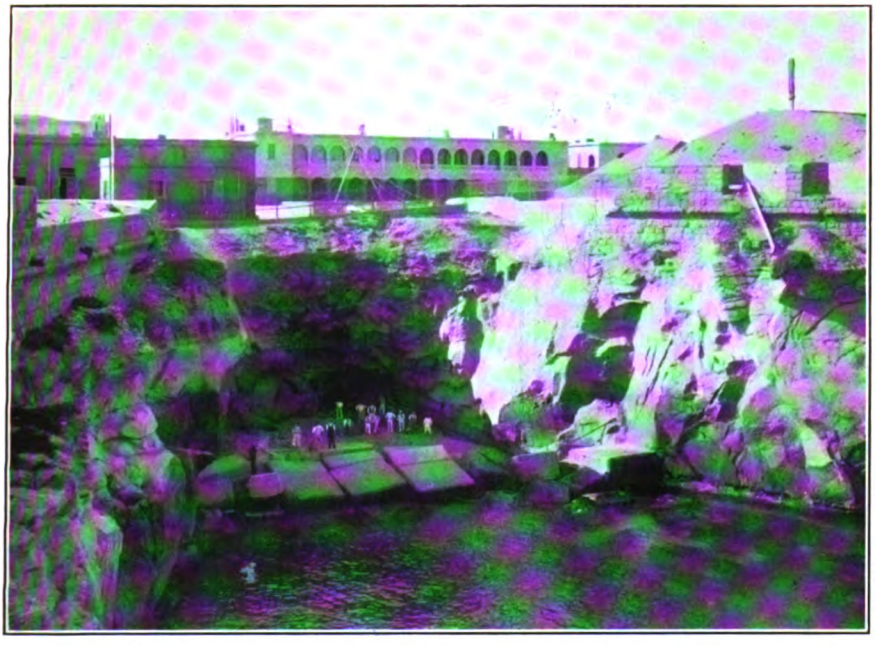

Photo A.—General view taken in September, 1912. On the extreme right can be seen the undercutting under No. 3 Curtain which will require attention shortly.

Photo B.—General view taken in September, 1912, when work on the last block was in hand. It shows clearly the breakwater; mouth of the tunnel and old wall built across it; fault in the rock above; retaining wall and fence put up in February, 1910; end of old bastion wall on right: Billiard Room: wooden fence round the cave and gear used for lowering materials down the cave.

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SEA ENCROACHMENT, FORT RICASOLI, MALTA.

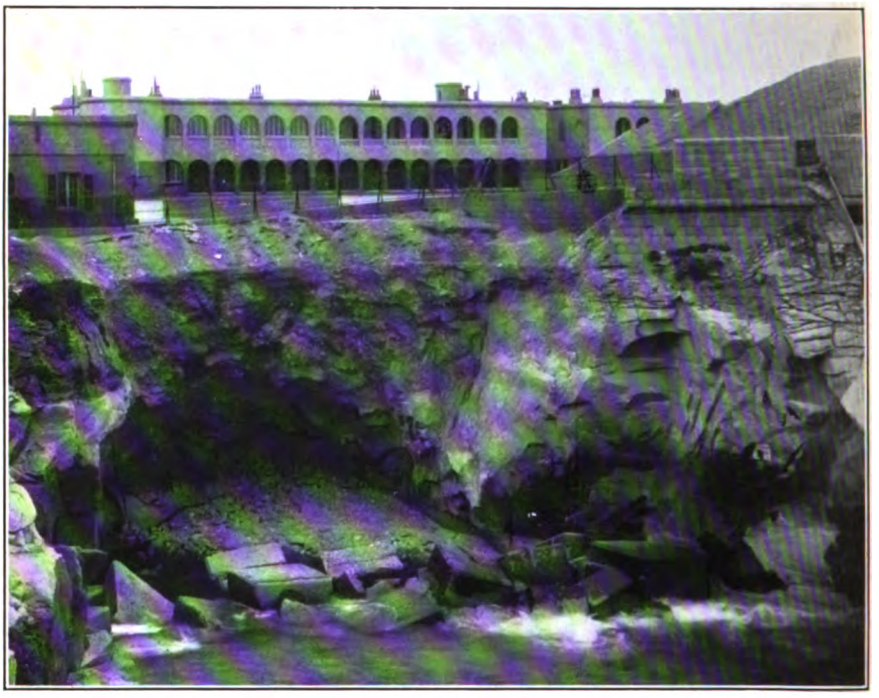

Photo C.—General view taken in April, 1913, showing the result of the winter seas on the breakwater; on the right can be seen where a piece of the cliff has been broken off; the mouth of the tunnel filled up with débris.

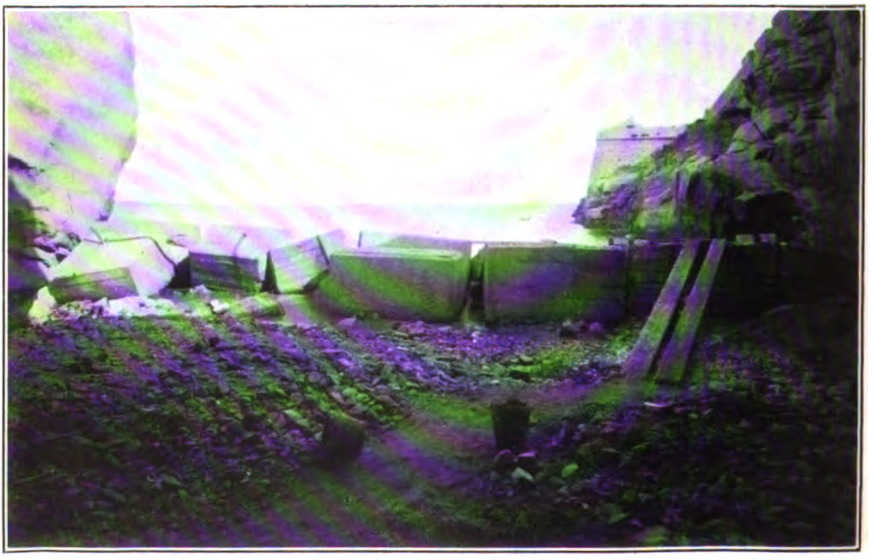

Photo D.—View of the breakwater from the mouth of the tunnel taken in September, 1912, when work on the last block was in progress.

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the photos) was moved slightly as shown by the mark on the cliff, but otherwise no movement at all took place on this side; on the right (left in photos) the blocks have been forced well back against the cliff, which is much undercut just here, and are now wedged well in, and should not be moved much more. The centre 50-ton block has suffered rather from a smaller and older block just in front which has eaten into it and made a cavity about 2 ft. diameter, and 1 ft. deep. The small material from behind the blocks has been piled up into the mouth of the tunnel. On the right of the photograph C there is a scar on the cliff face, showing where a piece of the cliff was broken away during the winter.

Summary.

Now that the action of the sea tends to force the blocks inwards instead of washing them out, it would seem that a satisfactory solution of the problem has been found and all that will be necessary on this site in the future will be the addition of these large blocks from time to time as found necessary, and the continued filling in behind them.

The results of the work here appear to prove that, in addition to the requirements laid down in the War Office letter of July, 1911, the breakwater required greater depth from front to rear, so as to have a much flatter slope in front.

An attempt to produce this flatter slope was made in 1911–1912, when a large number of blocks were made on the breakwater and then tipped forward to the front; the waves are also now helping by forcing the top blocks inwards and in course of time a breakwater with an outer face at an approximate slope of about 1 over 2 will probably be formed which should then require very little extra maintenance.

With regard to the actual work done, I think that the method adopted at the start was the only possible one which could have been carried out with local resources unless lighters had been used. Although the chain used was apparently not strong enough, and in consequence such a large number of the blocks were washed out to the front, still they made a foundation on which it was possible to make the blocks *in situ* the following year and also incidentally started to give the extra depth required.

Any additional blocks made in future should be of really good concrete and reinforced. I suggest 4 to 1 or even 3 to 1, and I consider that all external faces should have all air holes, etc., carefully stopped up. Care should be taken that the reinforcement is so placed that it is not likely to become exposed, as if this happens the action of the rust will probably tend to split the blocks.

The existing blocks were made on the loose top of the temporary

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platform and the bottoms are consequently rough and irregular. This was done to save the cost of the timber base which could not have been recovered if it had been used, but it was a mistake as it gave the waves something to bite into.

If chain is used it should, I think, be really heavy anchor chain, as the power exerted by the waves can be so enormous.

SUMMARY OF EXPENDITURE.

	£ s. d.	£ s. d.
1909–1910.		
Survey work, hire of boats		6 10 0
Diver		1 6 0
Removing earth from edge, and building retaining wall, and refixing fence :—		
Labour and material ..	172 0 0	
Cement	34 0 0	
		206 0 0
Making blocks, 5 tons, and fixing chains :—		
Labour, casing, spalls, etc. ..	99 0 0	
Cement	136 0 0	
		235 0 0
Purchase of chain and shackles		53 0 0
		£501 16 0
1910–1911.		
Lowering and shackling blocks		368 0 0
Extra work		56 0 0
Cement		25 0 0
		£449 0 0
1911–1912.		
Filling in behind breakwater with débris from bastion wall outside the fort		74 0 0
Purchase of lighter		16 10 0
Purchase of chain		1 10 0
Cement		*113 0 0
Labour on loading		3 10 0
Labour, watchman, casing, spalls, etc.		192 0 0
		£400 0 0
1912–1913.		
Cement		24 0 0
Labour, watchman, casing, etc.		161 0 0
		£185 0 0
Grand total .. £1,536 0 0		

* Includes £30 10s. for cement ordered for use in 1912-13.

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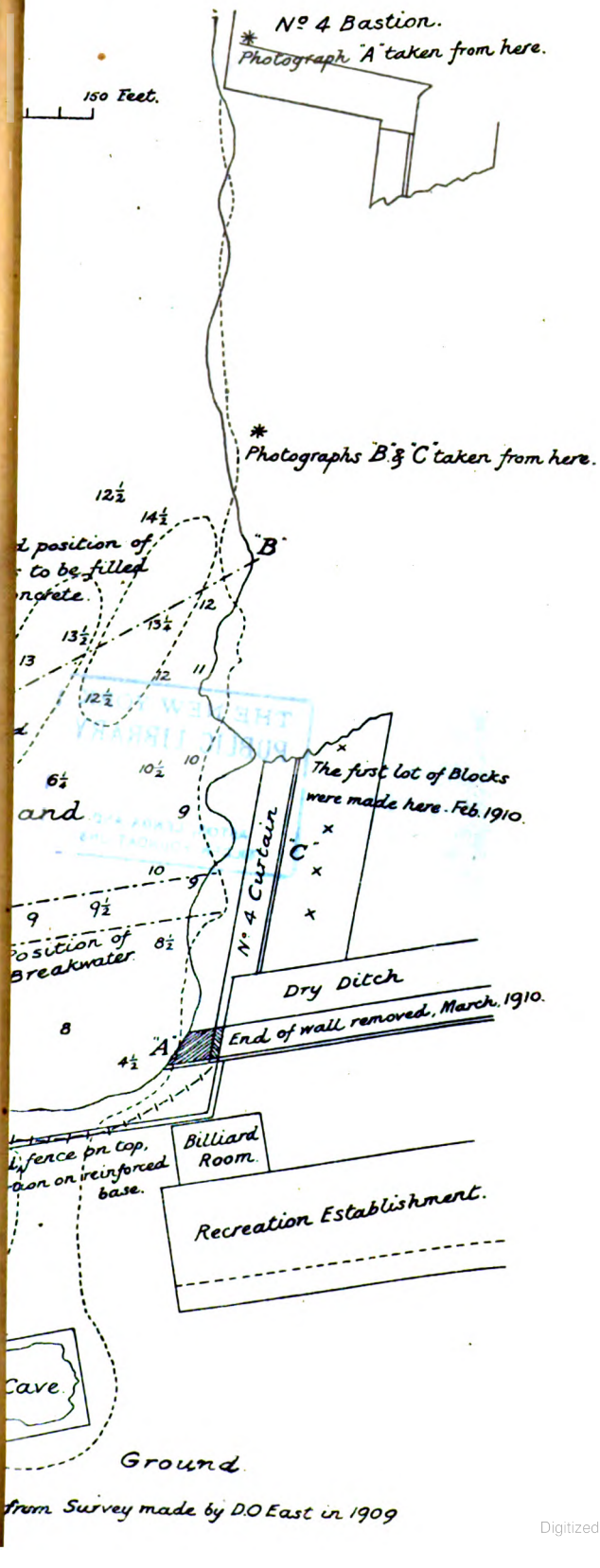
RT RICASOLI, MALTA.



from Survey made by D.O East in 1909

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SIEGES AND THE DEFENCE OF FORTIFIED PLACES BY THE BRITISH AND INDIAN ARMIES IN THE XIXth CENTURY.

(*Continued*).

By COLONEL SIR EDWARD T. THACKERAY, V.C., K.C.B. (LATE R.E.).

DESCRIPTION OF THE LINES OF TORRES VEDRAS.

With Graham's departure from Cadiz, the principal interest in the defence ceases, and although the siege dragged on till 1812, it ultimately proved unsuccessful.

In the present number it is proposed to deal with the Lines of Torres Vedras, which are referred to by Sir J. T. Jones in his *Sieges in Spain* as " a triumph of the British Nation."

The idea of fortifying the hills round Lisbon seems to have first occurred to the Duke of Wellington towards the end of 1809, when he realized how untenable was his position at Badajoz, and how necessary it would be for him to devise some different means of defence to enable him to resist the overwhelming masses which he foresaw would shortly be hurled against him by Napoleon. In his memorandum to Sir R. Fletcher dated October 20th, 1809, he commences with a clear summing up of the situation, and then instructs Colonel Fletcher to examine and report upon the defensive capabilities of the position under 21 separate headings. As Sir R. Fletcher's report confirmed Wellington's opinion, work was at once commenced upon the Lines, and was continued without a break right up to the time when the British Army, closely pursued by the French, entered the outer line of defence on the 8th of October, 1810.

The position thus fortified consisted of three distinct lines of defence.

The first extending from Alhandra on the Tagus to the mouth of the Zizandre on the sea coast, was, following the inflection of the hills 29 miles long.

The second traced at a distance varying from 6 to 10 miles, in rear of the first, stretched from Quintella on the Tagus to the mouth of the St. Lorenza, being 24 miles in length.

The third intended to cover a forced embarkation, extended from Passo d'Arcos on the Tagus to the tower of Junguera on the coast. Here an outward line, constructed in an opening of 3,000 yards, enclosed an entrenched camp, the latter being designed to cover an

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embarkation with fewer troops if such an operation should be delayed by bad weather. This second camp enclosed Fort St. Julian whose high ramparts and deep ditches defied an escalade, and were armed to enable a rear guard to resist any force. From Passo d'Arcos to the nearest part of the second line was 24 miles; from the first line it was two marches, but the principal routes lay through Lisbon, where means to retard the enemy were prepared.

Of these stupendous lines the second, whether for strength or importance, was the principal; the other two were subsidiary—the third being a mere place of refuge. The first line was originally designed as an advanced work, to stem the primary violence of the enemy, and to enable the army to take up its ground on the second line without hurry or pressure; but, while Massena remained inactive on the frontier, it acquired strength which was so much augmented by the rain, that Wellington resolved to abide the attack there permanently.

It offered five distinct positions from right to left as follows:—

1st. From Alhandra to the head of the valley of Calandrix. This portion 5 miles long was a continuous and lofty ridge defended by 13 redoubts, and for 2 miles was rendered inaccessible by a scarp 15 to 20 ft. high. It was guarded by Hill's Corps, and flanked from the Tagus by a flotilla of gunboats manned by British seamen.

2nd. From the head of the valley of Calandrix to the Pé de Monte. This portion also of 5 miles, presented two salient mountains forming the valley of Aruda, that town being exactly in the mouth of the pass. Only three feeble redoubts incapable of stopping an enemy were constructed here, and the defence was entrusted to the light division.

3rd. The Monte Agraça. This lofty mountain overtopped the adjacent country, and from its summit the whole of the first line could be seen. The right was separated from the Aruda position by a deep and blind ravine; the left overlooked the village and valley of Zibriera; the centre overhung the town of Sobral: the summit was crowned by an immense redoubt armed with 25 guns, round which three smaller works armed with 19 guns were clustered. The garrisons amounting to 2,000 men were supplied by Pack's Brigade; and on the reverse slope about 4 miles in length, Leith was posted in reserve.

4th. From the valley of Zibriera to Torres Vedras. This portion 7 miles long was at first without works, because it was only when the rains had set in that the resolution to defend the first line permanently was adopted. But the ground, rough and well defined, having a deep valley in front watered by the Zizandre now a considerable river, presented a fine field of battle.

Here Spenser and Cole, reinforced with a sixth division formed of troops recently come from England and Cadiz, were stationed under

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the immediate command of Wellington, whose quarters were fixed at Pero Negro, just under the lofty Secora Rock, on which a telegraph was erected to communicate with every part of the line.

5th. From the heights of Torres Vedras to the mouth of the Zizandre, the right flank of this portion and a pass in front of the town of Torres Vedras were secured by a great redoubt mounting 40 guns, and by smaller forts judiciously planted so as to command all the approaches. From these works to the sea a range of moderate heights was crowned with minor redoubts; but the chief defence there, after the rains had set in, was to be found in the Zizandre, unfordable and overflowing so as to form an impassable marsh. Such were the defences of the first line, strong, but at several points defective; and there was a paved road, running parallel to the foot of the hills through Torres Vedras, Sobral and Aruda to Alhandra, which gave the enemy an advantage.

The second and most formidable line also will be described from left to right.

1st. From the mouth of the St. Loureñca to Mafra. In this distance of 7 miles there was a range of hills, naturally steep, artificially scarped, covered by a deep and in many parts impracticable ravine. The salient points were secured by forts which flanked and commanded the few accessible points; but the line was extensive and a secondary post was fortified a few miles in the rear so as to secure a road leading from Eseceria to Cintra.

2nd. The Tapadas or Royal Park of Mafra. Here there was some open but strong ground, which with the Pass of Mafra was defended by a system of 14 redoubts constructed with great labour and care, well considered with respect to the natural features, and in some degree connected with the above-mentioned secondary post: the Sierra de Chypre, covered with redoubts, was in front and obstructed all approaches to Mafra itself.

3rd. From the Tapadas to the Pass of Bucellas. In this space of 10 or 12 miles forming the middle of the second line, the country is choked by the Monte Chique, the head of which is in the centre of, and overtops all the other mountain masses. A road conducted along a chain of hills, high and salient through less bold than any other part of the line, connected Mafra with the Cabeça, and was secured by a number of forts. The country in front was exceedingly difficult, and behind was a parallel and stronger ridge which could only be approached with artillery by the connecting road in front; but to reach that, the Sierra de Chypre on the left, or the defile of the Cabeça must have been carried. Now the latter was covered by a cluster of redoubts constructed on some inferior rocky heads in advance; they commanded all the approaches, and from their artificial and natural strength were nearly impregnable. The Cabeça itself and its immediate flanks were secure in their natural

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precipitous strength; so likewise were the ridges connecting the Cabeça with the Pass of Bucellas, wherefore, save the blocking of one mule path they were untouched.

4th. From Bucellas to the low ground about the Tagus. The defile of Bucellas, rugged and narrow, was defended by redoubts on each side, and a ridge, or rather a collection of impassable rocks, called the Sierra de Serves, stretched to the right of it for 2 miles without a break, and then died away by a succession of ridges into the low ground on the bank of the Tagus. These declivities and the flat bank of the river offered an accessible opening, 2½ miles wide. It was laboriously defended indeed by redoubts, water-cuts, retrenchments, and was carefully connected with the heights of Alhandra; yet it was the weakest part of the line, and dangerous from its proximity to the valleys of Calandrix and Aruda.

Five roads, practicable for guns, pierced the first line of defence; two at Torres Vedras, two at Sobral, one at Alhandra; but as two of these united again at the Cabeça, there were only four points of passage through the second line. Hence the aim and scope were to bar these roads, and strengthen the favourable fighting positions between them without impeding the movements of the army; the loss of the first line therefore would not have been injurious, save in reputation, because the retreat was secure upon the second and stronger line; moreover the guns of the first line were all of inferior calibre, mounted on common truck carriages, immovable and useless to the enemy. The allies' movements were quite unfettered by the works, but those of the French Army were impeded by the Monte Junta, which rising opposite to the centre of the first line, threw out a spur, called the Sierra de Baraqueda, in a slanting direction towards the Torres Vedras Mountain, and only separated from it by the Pass of Ruña, which was commanded by heavy redoubts. Massena had therefore to dispose his army on one or the other side of the Baraqueda which could not be easily passed; nor could a movement over it be hidden from the allies on the Monte Agraça, who from thence could pour down simultaneously on the head and tail of the passing columns with the utmost rapidity, because convenient roads had been previously prepared, and telegraphs established for the transmission of orders.

Such were the lines which, in the words of Sir John Jones, "are without doubt the finest specimen of a fortified position ever effected. Every objection heretofore urged against lines fail in application to those. From their peninsular situation there is no possibility of manœuvring on the flanks, cutting off the supplies, or getting in rear of them: in the details of the work there is no pedantry of science; no long lines of fortification for them without strength; mountains themselves are made the prominent points; the gorges alone derive their total strength from retrenchments. The quantity of labour be-

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stowed on them is incredible, but in no part has the Engineer done more than his duty ; assisted nature, assisted the general, and assisted the troops, and for each arm has procured a favourable field of action. For the militia there are nearly unattackable posts to guard the passes ; for the infantry, admirable fields of battle, suited to ensure and to profit by victory ; for the cavalry, spacious plains to which the enemy must arrive through passes rendered impracticable to their cavalry and artillery. No movement either forward or lateral is cramped ; on the contrary, one chief beauty of these lines is the facility afforded to communication : by a system of judicious and well-planned roads, the distance between each point and each corps of troops has been one-half shortened ; and from the precaution of having these roads commanded by works not to be reduced without artillery, they become useless to an enemy in case of accident or partial success ; and on the great scale, Nature has contributed much to this object by placing Monte Junta immediately in front of the centre of the line, the ramifications of which, extending to the very works, render the enemy's movements in front of the lines tedious and difficult, and give to a body of troops posted within, a superiority of movement rendering them equal to twice the numbers without."

These celebrated lines were great in conception and execution, more in keeping with ancient than modern military labours ; and it is clear that the defence was not dependent, as some French writers suppose, upon the first line. If that had been stormed the standard of Portuguese independence would still have floated securely amidst the rocks of the second line. But to occupy 50 miles of fortification, to man 150 forts, and work 600 guns, required many men, and numbers were not wanting. A great fleet in the Tagus, a superb body of Marines sent out from England, the civic guards of Lisbon, the Portuguese heavy artillery corps, the Militia and ordnance of Estremadura, furnished a powerful reserve to the Regular Army. The Native gunners and the Militia supplied all the garrisons of the forts on the second, and most of those on the first line ; the British Marines occupied the third line ; the Navy manned the gunboats on the river, and aided in various ways the operations in the field. The recruits from the depôts, and the calling in of all the men on furlough, rendered the Portuguese Army stronger than it had yet been, while the British troops reinforced from Cadiz and England, and remarkably healthy, presented such a front as a general would desire to see in a dangerous crisis.

It was however necessary to have the appearance of even greater strength, and Wellington therefore arranged with Romana, that without much attention to the wishes of his own government, he should join the allies with 6,000 men. Fortune aided the English general's efforts to increase the distance between Massena and Soult, and to diversify their objects at the moment he had concentrated the

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greatest force at the most important point; for before Septembe more than 120,000 men were rationed within the lines, 70,000 bein Regular troops.

Massena was surprised at the extent and strength of works whic he had only heard of five days before, and it is scarcely necessary t dwell upon the remarkable way in which they achieved their objec nor to show how they practically proved to be the turning point in th Peninsular War. The French Army when it arrived before ther numbered over 50,000 men flushed with victory, and although this forc was further reinforced by another 10,000, Sir John Jones estimates tha only some 40,000 men were left when Massena on the 5th of Marc determined to retire out of Portugal so as to save his army fron complete destruction. Even then, although he conducted his retrea in a masterly manner, his broken, starving troops were in no way match for their victorious adversaries. For one month Lor Wellington constantly harassed his retreating troops allowing then no respite, until he finally drove them over the frontiers in a state o sickness and misery which ultimately destroyed more of them thar any partial action could have done. No decisive action was fough during this pursuit, as in Wellington's own words he preferred "t harass them and send them out of the country as a rabble when from want of organization and from sickness, they will not be able to act for many months, and to keep my own army entire, rather than to weaken myself by fighting them, and probably be so crippled, as not to have the ascendant over fresh troops on the frontiers."

Finally, on the 5th of April the French Army recrossed the Spanish frontier, and Wellington halting his troops at Alfaiates gave up the pursuit.

(To be continued).

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A NARRATIVE OF THE SEVERAL TRANSACTIONS OF THE FRENCH IN THEIR ATTACK OF FORT ST. GEORGE, AND OF THE GARRISON IN THE DEFENCE OF THAT PLACE. ANNO 1758 *AND* 1759.

THE original manuscript of the following interesting account of the Siege of Fort St. George in 1758, has been presented to the R.E. Museum by Colonel C. F. Call, late R.E., and was written by his ancestor Mr. J. Call, the Chief Engineer during the Siege. In Cambridge's *Account of the War in India*, published in 1761, a large part of the diary was included but the opening comments were omitted. It is from this work that the accompanying map has been obtained, as it is missing from the manuscript.

It may be added that in the following account the original spelling and punctuation have been preserved throughout.

By Way of Introduction to the following Narrative of the Siege of Fort St. George I shall beg leave to make a few Remarks on the sudden Surrender of places lately besieged, and endever to vindicate the Art of fortifying from the unjust reflections cast thereon. I shall then show the Motives which induced Mr. Lally to form a regular Siege ; and conclude with enumerating the advantages the besiegers generally have over the besieged.

The Superiority of Attack to Defence has seemingly been confirm'd by so many Instances within this last Century that it has almost establish'd a Maxim among Engineers as well as others. " That 'till some new System of Fortification is invented it is impos- " sible any Place can withstand above a few Days the rigorous " Method of attacking now in Use." And another " That a Place " besieged is lost." This I grant is apparently the Case ; and the Number of places taken have given great Room for Experience and Improvement in the Art of Attack while in the additions made to old Enceintes in the few Places lately built the Engineers of that Class have been confin'd to an old Plan, or those Systems establish'd by the great Names of Coehorn and Vauban beyond the Authority of Modern Artists. But if we look farther (tho' I allow and shall prove that besiegers have great advantages) it will perhaps appear that very few Places have had Justice done them in the Defence : To discover this we need only cast an Eye over the Plans of Places (many of which were famous for the Strength of their Fortifications)

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taken with a rapidity scarce to be imagin'd in the last War. It will from thence appear that most of them were surrended by a Capitulation and that too before the breaching Batterys were constructed; others in which a breach was made, never stood an Assault, except Bergen op Zoom; and it is confidently reported there was either Treachery, or to say no Worse an unpardonable neglect in the Disposition of the Troops for the Defence. How then can the blame be thrown on the Works which are but secondary Means of Preservation, and have seldom or never of late, been made use of to extremitys. 3rd If Policy to preserve the Effects and Priveleges of the Inhabitants of a Town, or to prevent that often threatened butchery the consequence of a Place taken by Assault; or lastly if preserving the Liberty of so many Troops to a State; I say if these are admitted as sufficient Motives for surrendering a Place still the Works are not to be blam'd. But if instead of these Considerations a mere pageant Form of Military Honors in the Manner of losing a Town, has any weight; and if it is admitted as a Point of Consequence to obtain leave for the Governor at the head of his Garrison to march as far as the covered-way and there surrender Prisoners, I say if this is sufficient to save the credit of an Officer who wou'd defend a breach at the hazard of his Life and Fortune when so fair an opening is given him to save both? And how easy then is the Fate of a Place determin'd when the Commanding officer of both Partys aims nearly at the same End; the one to gain honor by making a breach, and the other to save his 'till a breach authorizes a Surrender. 4th Not such was the Behavior nor such the Motives of the Governor and Garrison of Fort St. George; the consequences too were different, and it has been prov'd by a conviction glorious for them, that an heap of Earth may be defended when an honest Resolution animates the Defendants. Shou'd it be urg'd that the Fortifications of Fort St. George were too formidable and the Garrison too numerous to be attack'd with any View of Success by so small a Force as Lt. General Lally commanded before it; I shall allow that as these Matters are usually considered it had the appearance of a vast Undertaking. But to state the Matter clearly let us take a View of the Motives which encouraged the Attempt; and it will appear in the Course of that Consideration, that the Disposition of the Garrison and appearance of an obstinate Resistance to the last extremity, intimidated the Enemy, and prov'd a greater Security to us than cou'd be imputed from the ruinous Condition of our Works. 5th The View of the French Nation in sending out at an immense Expence such a Number of considerable officers and so large a Force as Lt. General Lally brought with him cou'd be nothing less than the entire destruct. of the English possessions in the East Indies. Mr. Lally soon recd. encouraging earnest of Success in the easy Reduction of Fort St. David, the reputed Barrier to his Conquests, and he no

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doubt wou'd have pursued his blow by attacking Fort St. George even in the hottest Weather, had he not been aw'd by the presence of our Fleet. The removal of that obstacle to Bombay and the junction of the French Forces from the Decan, having furnish'd an opportunity of pursuing his Projects, he took the necessary previous Steps in October. He well knew that we never shou'd be weaker than at that Juncture, and he had soon after the satisfaction to hear that our expected Succors were on the Malabar Coast, and consequently coud not be with us till late in Janry. Notwithstanding this Mr. Lally did not perhaps at first intend a regular Siege but on weighing well the Strength of his Situation in the black Town, the convenience of a strong Post at St. Thomé, and the advantages to be drawn from the proximity of the houses to the Glacis of the Fort, he had some reason to think it might be possible for 3,500 Europeans to carry on Approaches against Fort St. George tho defended by more than 1,500. In this too he was the more confirm'd by the lucky Arrival of the *Haarlem*, which Ship he had providentially sent to Mazulipatam in October with battering Cannon; and by the easy Conveyance for Most of the heavy Stores from Pondichery by Sea. Thence many of the Inconveniencys apprehended from leaving Chinglaputt in our Possession, and from the black Army which he knew we expected from Tirichnopoly, were in great measure remov'd; and Mr. Lally found himself in a Condition to erect Batterys against the North Front which he determind to attack by advancing along the sea side, and breaching the Demy Bastion. This appear'd to him the easiest approach and the weakest part of the Town, in which opinion many of the Defendants concurr'd, but for my part I always thought the contrary, notwithstanding the facility of advancing where our flank is covered by the sea. However this is not material, he knew that the Fortifications were chiefly temporary, and these incompleat, he also knew the Town was pretty large and not wholly secure against a Coup de Main; that the Garrison tho' numerous with respect to the Assailants must therefore be attentive to every part, and that the Duty must consequently be very hard, or but few Men posted on the front attack. All these Circumstances were really true but I am persuaded he was farther actuated by the easy conquest of Fort St. David which every one deem'd stronger than Fort St. George, and the mean opinion he conceiv'd from thence of our Military Force directed by a Council of Merchants; whom from their opposite Professions to War, and apprehensions for their possessions and Effects, he imagin'd wou'd soon incline to a favorable Capitulation. But how was he here mistaken! This Council of Merchants so much despis'd had provided every thing necessary for a long Siege, and by the regular distribution of the several Employs among themselves and others aided by the great activity and exemplary Encouragement of their Honble

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President, it is allow'd no place was every better supply'd or more cleanly kept. Nor did ever Garrison bear with greater resignation the hardships of a Siege, or Inhabitants behold with less uneasiness the destruction of their houses and Effects. Thence it arose that no thoughts were entertain'd of a Capitulation, and that the general discourse even of the common Soldiers turn'd on the Defence of the breach and the Slaughter they wou'd make if the Enemy attempted an assault.

Of this Mr. Lally was long ignorant and encourag'd by our cautious Defence ; he flattered himself if he cou'd once gain the covered Way, the Affair wou'd soon Terminate : He therefore advanc'd by a very paltry kind of flying Sap and Crochets to the top of the Glacis, without any great loss ; where a breaching Battery was establish'd against the Demy and North East Bastion without regarding the North Ravelin or the Orillon Flank of the Royal which defended the Bastion attacked with 6 Guns. In this Mr. Lally propos'd to follow the Method he had seen practis'd by Marshall Lowendalh at Bergen Op Zoom, but he soon found he had a Garrison differently dispos'd to deal with ; and tho' he added the Terror of a Mine to that of his Battery, he perceiv'd no Signs of a Capitulation. On the contrary his Battery was soon silenc'd, Numbers of his Men daily destroyed, and preparations making to blow up both if they had continued longer ; He therefore began to fire again from his grand Battery without trying the effect of a threatening Summons ; and after unsuccessful attempt to push on by the Sea, he was so thoroughly convinc'd of our steadiness, and the obstinate resistance he shoud meet with that he prudently resolv'd to retire.

Thus have we describ'd Mr. Lallys pressing Motives for attacking Fort St. George, and his method of proceeding therein ; from whence it has been seen how 3500 Europns. regularly besieged near 1600, tho' frequently oblig'd to make large Detachments and undergo severe Skirmishes with our black Army. Nothing I imagine but the critical conjunction of Time, the absolute necessity of possessing Fort St. George before he cou'd execute the remainder of his Plan, and the vast advantages which wou'd have follow'd such a Conquest, cou'd have induced Mr. Lally to undertake a Siege with forces so far short of the usual Proportion between the besiegers and the besieged : But if every disadvantage of the Defendants be consider'd, I think it will in general appear that the assailants have the fairest chance of carrying their Point ; and I am sure I can prove in our own Case, that the Enemy to the last had men sufficient to make an assault had things been brought to a proper Crisis.

In every Place besieged whatever Care has been previously taken a thousand things must still be done when the Place is invested and the Front to be attack'd discovered ; These bring hard Duty on the Garrison which added to offensive Smells, want of many little

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necessarys and a confin'd Air soon occasion extraordinary sickness among the Soldiers, especially when there is a want of secure Places to rest in, and no Inhabitants or Laborers to ease them of working Duty. The daily destruction among the Troops the ruins of the Works and houses, and the constant appearance of the Enemys advance, seconded by reflections that every place lately besieged was taken certainly introduces a share of despondence among the most resolute Garrisons. On the contrary the besiegers have every thing to encourage them: First plunder of the Suburbs; then hopes of plundering the Town; the Liberty of roving at Pleasure the Plenty of Provisions; the constant destruction they behold of some object by every shot and shell they fire; and lastly their daily advances and the Garrisons retreat, are so many Inducements for them to prosecute that Labor, and undergo the fatigues which are to compleat their Wishes.

I do not pretend to say what I have described was exactly the Case with the besiegers or the defendants of Fort St. George, but I am persuaded it happens in almost every other place; and I also know that after the Sally of the 14th we had only 1377 effective Troopers, Artillery and Military, of which 100 were constantly employ'd as Pioneers, and the Enemy had then 3300 men; By the middle of the Siege we were reduced to 1000, and before the End of it we had not full 800, so that granting 300 were on Duty every Day, still we cou'd not oppose 50 men in any Work of the North Front, and in most we had not half that Number. The Enemy had by Mr. Lallys own Letter 2000 effective Men the 14th Febry; Now had the breach been wholly practicable what advantage must the besiegers have had; who being masters of their Method and Time of Attack cou'd purposely have favor'd their men, and fallen on with vast superiority in three or four Places; while the Garrison equally attentive to all and unappriz'd of the Enemy's Intention must have fought with very unequal Numbers and cou'd hardly expect a support till the contest was decided? For my own part I sincerely wish we had three to one against Pondichery, or only 4500 men to attack Mr. Lally and 2000 French in it. I think the conquest wou'd be certain; expecially if we were once advanc'd to the Counterscarp, and our Cannon had breach'd the Walls. Not that I esteem the French bad Soldiers, on the contrary they ought from experience to be good ones, but I know the place is too large and too weak, to be defended against any reasonable force skilfully conducted.

I hope the example of the Garrison of Fort St. George will not long be singular, but that every British Town which shall be attack'd in future will be defended with the same laudable Resolution, and the Consequences be as valuable to the Nation as the preservation of Fort St. George has been to the East India Compy. On the Fate

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of this Place their very Existence depended; for it is hardly to be doubted but Mr. Lally wou'd have push'd his Conquests to Bengall as soon as he had reduc'd the English Settlements on the Coast of Coromandel; and the Instant Monsr. D'Achér had been superior to Admiral Pocock, Bombay must have fallen. The same dismal scene of Destruction woud have follow'd each of these when conquered as has been practis'd at St. David, and Fortifications which have cost near a Million Sterling woud have been reduced to an heap of rubbish. These Consequences the Govr., the Council, and the principal officers in Fort St. George had thoroughly considered and instead of dreading the Danger that threatened them, they determin'd bravely to oppose that destruction which seem'd to threaten others, and resolv'd if possible to avert it at the expence of their Lives and Fortunes. A Resolution glorious in its nature! and worthy Emulation: And which his Majesty, the East India Company, and the whole Nation will doubtless reward with those distinguishing Marks of approbation due to such uncommon Zeal for their Service.

Before I enter on the Siege it may not be altogether improper to say a word or two of the Motions of the French Army previous to the Investiture of the Place. After General Lallys return from his unsuccessful expedition against Tanjore, he canton'd his Army in Gingi, Wandewash, and Chettaput: and sent a party to Carangoly which we had abandoned: We had done the same by Chinglaputt, but after the arrival of Colonel Draper, and part of the Battalion, it was garrison'd again, and resolved to be maintain'd. The Enemy about the latter End of October gave out, that they actually intended to besiege Madrass; but our expectations of the rest of the Battalion; the approach of the Monsoon; and the necessity we imagin'd they wou'd be under of first taking Chinglaputt; made us conclude they wou'd scarce be in a Condition to undertake such an enterprize; especially as we estimated our Garrison as equal to half their force. However we had certain advice of Cannon being put on board a Ship at Pondichery, and of Mortars, and other stores collecting at Carangoly. In the beginning of October the French moved to Arcott; took that place; and return'd soon after to Conjiveram, from whence they sent a Party up to dispossess us of Tripassore which being indefensible we abandoned to them. While the Enemy continued at Conjiveram they collected great quantitys of Ammunition, and other Stores, and were join'd by a body of 500 Men from the Army which Mr. Bussy had long commanded in the Golcondah Province—About the beginning of December Mr. Lally imagining the Monsoon at an End moved with the greater part of his force to [a] Trepermadore, and gave out that he wou'd invest

[a] A Village about half way between Madrass and Conjiveram.

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Madrass immediately ; but they next marched to Chinglapermacoil with a design as we imagined to make some Attempt on Chinglaputt,* *but we have since learnt that Mr. Lally having received advice that our Reinforcements were on the Malabar Coast, and consequently not likely to be at Madrass till February a Council was call'd, and a Resolution taken of attacking our Capital without attempting Chinglaputt.** Accordingly the Enemy moved to Vendalore, and Colonel Lawrence who had about 1,000 of our Troops at the Mount, knowing the Strength of his Situaton never cou'd impede the Enemys advance to Madrass, retired to Choultry plain, and from thence the 10th December at night to the late Dr. Munros (at present Mr. Turings) Gardens, and some adjacent topes ; which Post had been chosen that Day for the strength of its Situation, and was intended to be fortifyed the next morning. The Avenues from St. Thomé were to have been barricaded, and two small Guns with an officers command were sent to Egmore Redout ; so that it was thought by this Disposition the Enemy wou'd find it very difficult to approach Madrass. However by day light the 12th in the morning the greater part of their Force was seen near the ground our troops had quitted in the night, where we canonaded them an hour or more, and then observing that the Enemy were making a disposition to attack us, Colonel Lawrence with Reluctance, tho' in obedience to his Instructions founded on the expectations of our Succors, retreated in good order to the Island, as did the party at Egmore, and a body of Seapoys who were dislodged by the Enemys black Troops from St. Thomé. Our whole Force being thus united several partys were sent to possess the Avenues at the Entrance of the black Town, and the rest marched into the Fort.

12th. The Enemys main Body encamp'd on the Plain near Turings Gardens, but some picquets were lodged at the Companys Gardens, and Mr. Stevens's. Nothing else remarkable happened this day between the Enemy and us, they seem'd to be reconnoitring the South, and West Fronts, and we were busy in making general dispositions for our Defence.

Wednesday 13th. This day the Enemy seem'd to be reconnoitring the South and West Fronts, which gave us an opportunity of firing a few Shot at their Partys from some field Pieces in the Black Town,

* And most certainly the conquest of that Place was their intention from which nothing cou'd have diverted them but the important advice Mr. Lally then received of our Reinforcements having been on the Malabar Coast : In Consequence of such Information a Council was called of the principal officers and a Resolution taken that no Time was to be lost, but an immediate Attack to be made on Madrass without attempting Chinglaputt.*

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but nothing very material past between us. The South Side where two new [a]Works were just begun being by far the most exposed to a Coup de Main which it was strongly presum'd the Enemy wou'd attempt, a Field officer with a Stout party was sent to lie all night in the South covered Way, and the strictest orders given to the officers on the other Post to beware of a surprize, which was the more to be apprehended from the Number of people, Cattle &c.[a] crowded on the Glacis, and under the Works round the place. Three posts which we held in the black Town were also reinforced, not with a design to make an obstinate Resistance, but if attacked to do the Enemy what Prejudice they cou'd, and retreat towards the Fort in such a Manner as to run no risque of being cut off. The Number of Troops on Duty yesterday, and to Day, was so great that I found it impossible to get any appointed for a working Party; and confusion prevailed so much among the blacks, that I cou'd only secure some of the Mistrys, and a few Common Carpenters, and Smiths. The Deserters who come in pretty thick, inform us that the Enemys force when united will be full 3000 Europeans of which 400 are horse that they have no heavy Cannon or Mortars but expect some daily, Their Black force may be about 2000 Horse and as many Seapoys.

Thursday 14th. The Enemy having marched from their encampment about the middle of the night, entered the black Town on the North, and West about three this morning; The opposition they met with from our Sepoys, and Europeans, posted at the several Passes was very trifling; but by good fortune our people got all safe to the Fort. By day light the Enemy were in full possession of the black Town, hoisted their Colors soon after at the Armenian Church, and fired some scattering Shott at our people on the Glacis from the Tombs at the burying ground. Lieut.-Colonel Draper making an offer about Eight O'Clock to attempt dislodging the Enemy while they were yet unsettled, and perhaps plundering, a body of 350 men or more and the two Granadier Companys were paraded for that purpose. With these and two field pieces he marched out at St. Georges (or the western) Gate and passing quickly over the bridge into the Pittah *Detached Majr. Brereton with 150 men along under the hospital hill as denoted by the black dotted Line to observe the Enemy on that side while he Col. Draper with the remainder and the Guns* marched thro' the Street as shown by the dotted Line, (1) till he came to (3) where he perceived some of the Enemy and received a scattering fire; to check them he left two Platoons and marched on with the rest to the position (6) where he had a fair View of the Lorraine Regiment and Indian Battalions on the flank

[a] Vide Plan.

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at (4) for they expected him in another Street a little higher up (2) and had pointed 4 Guns in that Direction. Our Cannon at (6) began to play briskly with Grape and with the Musquetry made such havock among the Enemy that they soon fell into Confusion and ran across the Street under cover of some hutts. Col. Draper then advanced towards their Guns from which they had only fir'd three shot, and exchanged a Pistol with the officer, who offered to surrender them, but in spite of all his entreaties only four Granadiers wou'd follow him, the rest of our troops having like the Enemy thrown themselves in among some old Walls and under cover of houses kept a popping fire on each other. This gave the Enemy time to rally, and confusion became so visible among our people that Col. Draper thought it most prudent to retreat which he begun by Marching down the street as the dotted Line (8) Shows, but unfortunately above 80 of our Men not paying a due regard to the motions of the rest were shut up in the square (7) by the Enemy and taken Prisoners; this in some measure stopt the Enemys pursuit, and Col. Draper being joined at (b) by Major Brereton who had marched to support him with a party of 150 men he left his Guns, and continued his retreat with little loss to the Fort, notwithstanding the Regiment of Lally came from the Armenian church to the little bridge (10) and with 2 pieces fired Grape at our troops passing along (8) but they mostly fell short. Cou'd Regularity and obedience to the officers orders have been preserved among the Men in this Sally, it might in all probability have prevented the Siege of Madrass, and have ended in the total over throw of the Lorraine Regiment, and the two Battalions of India; As it was they had 30 officers or more killed and wounded, and near 300 men besides the Count D'Estaing, a Brigadier taken Prisoner in the beginning of the Action. Our Loss of men was 103 taken, of which 19 were wounded, about 50 left dead on the spot, and the same Number came in wounded; so that we suffered a Diminution of more than 200 men, and 9 officers. The Enemy during the Sally fired several Shot from some field pieces into the Fort but did no damage; they were quiet the remaining part of the Day, and we only fired a few Cannon on those places where we imagined they were at work. Count D'Estaing desiring leave to write a Letter to Mr. Lally it was granted, and a flag of truce sent with it. A Letter was wrote at the same Time from Colonel Lawrence recommending our wounded Men, and officers to Mr. Lally's humane treatment; which by his Answer he assur'd him they shou'd have, in the same manner as his most Christian Majesty's Troops.

No Europeans were to be had this Day for a working party, but I luckily collected a few Cooleys, Bricklayers, and other Artificers, and set them to make a Dam in the Gut at (c) to shut up the Communi-

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cation between the Water in the River and Ditch, lest the Enemy shou'd cut the Dam (d) which kept up the Water two feet or more, and thereby drain so much off. This was a piece of work on which much depended, and which with difficulty I got finished before night. I also set up a Pallisadoe in an opening under the South Flank of the Royal Bastion, (e) and remov'd some Gabions, Fascines, and other Materials which were in the Way on the Ramparts.

15th. Several Deserters have come in from the Enemy this Day and Yesterday, who all agree in their reports that the Enemy lost many men and officers in Yesterdays Action. The Enemy fired not a Shot this Day from Cannon or small Arms, nor have they been perceived any where at Work, tho' we have many informations of their erecting Batterys, and fire now and then at the suspected Places. We cannot learn yet that they have any Mortars or heavy Cannon with, or near them ; but tis said a Ship is coming up with all kinds of Store from Allemperva. By the Enemy's reconnoitring and Situation it seems as if they intended to attack the North Front by the N. East Angle. I therefore considered what was most necessary to be done to oppose them, and resolved to compleat the blind which I intended before the Old N. East Bastion, and to erect a Fascine Battery on the Glacis before the Shoulder of the East face of the North East Bastion ; which Battery is to reach quite down to the Surf, and intended to sweep under the bank of the Glacis which had been cut down by the Sea, and afforded good cover for an Enemy. It was also Determined to set up a Pallisadoe before the Sea Gate, and to close up with stones the small Gate on each side the large one. A Captain, Two Subalterns, and 100 Men besides all the blacks I cou'd collect, were ordered on the above Services, with Messrs. Leigh, Eiser, and Stevenson Engineers.

16th. Yesterday evening I had orders to prepare people with proper Tools to cut away the floor of the Bridge leading from the West Front to the Hospital Hill, and to remove the old Draw Bridge which lays over the Canal on the Saliant Angle of the Royal Bastion. I accordingly ordered a party of Lascars and Cooleys under Mr. Leigh to perform the latter piece of Service ; and some Carpenters under Mr. Stevenson, to be on the former, each of which was to be covered by a party of 12 Granadiers, and the Work to be performed between Eleven and Twelve ; but the whole was countermanded, because it was apprehended we might suffer from it greater Inconveniencys than the Enemy. A Party of 40 Voluntiers, and 40 Sepoys were this Night order'd out about Eleven o'Clock to give the Enemy an alert, and if possible nail up some pieces of Cannon which it was said were in the black Town, but they had not proceeded much beyond the Glacis before the Enemys advanced Centinels gave their fire, and alarmed their whole force, so that our party on

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hearing the Drum beat to Arms retired. A Party of 100 Soldiers, and 65 Sepoys were this morning paraded for working, and distributed chiefly to the Works mentioned yesterday, which were nearly finished by night; and the Pallisadoe round the Sea Gate Virando entirely compleated. Fascines were also laid round to form a Parapet on that part of the Sea Gate Battery which had none; and some sand Bags laid for the same purpose in part of the Barbet Battery towards the Sea. Earth was also laid on the Arch over the Magazine under the old West Curtain and over part of the hospital adjoining.

17th. Last night about Eight o'Clock the Enemy gave an Alarm by a few Men coming near the Glacis, and giving their fire. Nothing remarkable happened afterwards. This Day 100 Men, 2 Serjeants, and 1 Corporal were on a working Party but the Weather being very rainy, little was done. They, and about 200 Blacks were chiefly employed on the two batterys mentioned the 15th to the N. East, in thickening the Parapets of the old N. East Bastion; compleating the Barbet Battery with sand Bags; laying Earth on the hospital Arches, fixing a Pallisadoe to close the Communication from the Covered Way on each Side to the North Ravelin, and repairing some Checks of the Embrasures on the Demi Bastion; besides other trifling repairs. The Enemy was not for certain perceived to be any where at work; tho' single Guns (by Way of security in the night I suppose) were perceived in some of the Streets. Very few Shot were fired by us and less Shells during this Day. Several Deserters came in last night and this Evening, from whom we learnt the Enemy had some Mortars arrived at St. Thomé. The Governour this Day gave it out publickly that he wou'd distribute 5000£ among the Garrison five days after the Siege was rais'd or the french beat off.

18th. This Morning it was perceived that the Enemy had thrown up a breast work (Vide Plan A) from the houses on the beach near the old Town to the Sea Side, but whether intended for a Battery, or to prevent any attempt of ours on their flank cannot be said, tho' I believe the latter because the trench from whence the Sand has been taken is on the side of the Enemy contrary to the Method of making Batterys; something of the same kind was perceived in the Streets next the Sea, but no Guns or Mortars have yet been fired, or appear'd ready for that purpose. On our Side a very few Shot or Shells were thrown. The Gentlemen of the Squadron, and Marines, who had been on board a Dutch Snow the 12th with an Intent to go and take the French Ship which is coming up with their Stores, were this morning landed being very unwilling to undertake the expedition, and having been detained by bad weather so long in the road, that it was supposed they were discovered. Captain Jasper who was

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to have commanded them appeared much chagrin'd at his Disappointment, and indeed with reason, for had he succeeded, and I think he had great reason to expect success, nothing cou'd have done us more service, or the Enemy greater Prejudice. A great many people were perceived to Day moving from the Mount towards the black Town, which we apprehend are bringing up the Enemys Stores. It is very remarkable that 33 deserters have come in from the Enemy since their arrival, and not one man has deserted from the Garrison or been seen in Liquor.

A Peon came in and informed us, that Captain Preston had sent out a Party under Lieut. Airey from Chinglaputt, which had intercepted a Convoy of the Enemys stores consisting of a Large Mortar which he spiked up, and burnt the bed, 2 Guns which he also spiked, and burnt the Carriages; and some Ammunition which he carried off with all the bullocks. No Deserters last night, which is owing I suppose to some extraordinary Care or orders of Mr. Lallys. The Working Party was this Day about 100 Men without officers. They, and the black Artificers were chiefly employed in fixing a Pallisadoe before the new Battery by the Sea Side, opening another embrasure in that Battery, cutting down the high bank which the Surf had made by washing away the Glacis; thickening the parapets of the old North East Bastion; repairing the embrasures with Palmeiras which had been blown away by our own Guns; laying Earth on the hospital; fixing a Pallisadoe in the Gorge of the North Ravelin; and repairing a Dam (c) which had been made in the Gut to the North West to keep the Water in the Ditch, but the Water had rose so high by the last four Days rain, that half the Dam was destroy'd, and the Water considerably sunk. Several other Jobbs of a trifling nature were also executed.

19th. This Morning we perceived that the Enemy had thrown up another breast work about 50 feet in Length and 100 Yards or more advanced before that thrown up the preceeding night. Both these Retrenchments terminate on the Surf the latter at the distance of about 500 Yards from the N. East Saliant Angle of the covered way, and seem rather intended to cover a Guard posted there to prevent a surprize or desertion, than for any annoyance to the Fort. However from the proceeding of the Enemy it appears as if they intended to advance along the beach, and attack the Demi, and North East Bastions; it is therefore resolved that Platforms shoud be raised in the covered Way sufficiently high for field Pieces on covered Way Carriages to fire over the Parapet. It is further resolved to raise the Parapet of the Demi Bastion near the saliant Angle two or three feet higher than the rest, and to erect a Traverse on the East wing to prevent an enfilade. To raise the blind before the N. East Bastion so high as will just admit the Guns to fire over

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it at the Enemys Works. That the passage between the upper, and lower flank of the Demi Bastion shou'd be closed in the securest manner, and that the North Ravelin shoud be put in the best condition of Defence we might have Time or Workmen to do. The Working Party of about 100 Men with such Cooleys, Pallankeen Boys, and others as I cou'd collect, were set about the several Articles before mentioned. The firing on our side was very little to Day except from Wall pieces, and not even a musquet Shot came from the Enemy. Five Chalingas were seen this morning going out of St. Thome Bar, and saild to the Southward, as we apprehend for Stores.

20th. Last night the Subaltern on Duty in the N. East Angle of the covered way with 21 Men, and some Sepoys, was ordered to Sally on the Retrenchment and works which we supposed the Enemy was carrying on, but it being rather too light, they were discovered and the Sepoys taking a Pannick at a party of 6 horse which appeared, ran away, which intimidated the Europeans, and they, after giving their fire retreated also without doing the Enemy any other Damage I believe, than giving an alarm. We were not so fortunate, for one European was killed, and two dangerously, if not mortally wounded: The Sepoys suffered in the same manner. The Commandant of Sepoys Pemaul Saib being desirous of attacking St. Thomà last night was sent out with 10 Companys of Sepoys, but taking the direct road over the long Bridge he was discovered by a few French Sepoys at Mr. Powneys house who gave him a few Shot and his people many of them threw down their Arms which induced him to return without performing the least piece of Service. The Enemy we cou'd perceive this morning had been at work last night and to appearance drawn about 50 Yards of a Parrallel westward from their most advanced Breast work. They also had got a Gun behind their first breast work, and from thence fired several Shot at the Snow which lay in the Road under Dutch Colors. The Shot mostly fell Short, one or two entered, and killed a Lascar; the Vessell therefore weighed and stood a little farther off, as well to avoid any annoyance from thence as to prevent a Surprize. A Mossala appearing off St. Thome, a Party of Marines were sent in three Mossulas to fetch her in, which they effected, and found her to be a boat going from Sadrass to Pulliacat. The Working Party was this Day 100 Men, and employed as Yesterday except on the old N. East bastion the Parapets of which were finished. This afternoon the Artillery Serjeant on the N. East Bastion intending to fire a discharge of Grape at some of the Enemy which appeared at their Breast works, unfortunately some scattering Shot fell* into the

* Grape Shot in Spite of the greatest of Care spread and drop so much that tis not safe to fire from any work while any of your own Troops are posted in the covered way or near it.

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covered Way, and miserably wounded three Cooleys, who were rolling a Gabion upon the Work there carrying on.

21st. Last night we fired Shot or Shells every 8 or 10 minutes on the place where we suspected the Enemy wou'd work, and by that means prevented them from doing any thing more than throwing up an imperfect Communication from the first to the second breast work. Advice being brought in last night that the Enemy had 2 Guns at Trivelcane and very few Troops at St. Thomá about 10 o'Clock in the morng. near 1000 Sepoys with 20 Europeans Commanded by Town Major Bannatyne and Ensign Crawley went along the Beach to the Southward, cross'd the Bar, and march'd thro' the Village beyond the Governors Gardens, where they surprized two or three Small Sepoy Guards, intercepted some Letters, took a troopers horse and Arms, and one Soldier Prisoner, but on advancing down the road towards Mr. Turings house, they perceived a body of Europeans and blacks, which they were not a match for, and therefore returned by the Way they went. From the Fort house we perceived in the mean Time 2 Guns perhaps 18 or 24 Prs. the one drawn by Bullocks 15 or 18 Yoke, and the other by Bullocks and Cooleys passing from Chind-adree Pagoda across the Plain towards the Potters Village, but being near enough for our great Guns to reach them, some shot were immediately fired from the Nabobs Bastion and Lawrences, which soon made the Cooleys and Bullocks halt, and one of the Guns sinking almost to the Axle Tree at the same time, it was proposed to send a party of 300 Sepoys with a promise of a great reward to nail up the Cannon. They were accordingly sent out at the western Gate on the sight of which and our firing, the bullocks were cast off from the Guns, and the Cooleys ran away, leaving the Guns alone. Our firing and the Motions of the Sepoys alarm'd the Enemy in the black Town, so that about 200 European horse were sent in all hast towards the Guns, and their foot marched to the west side of the black Town to support them ; This we perceived and fearing the Sepoys might be cut to pieces sent orders for them not to advance beyond the little bridge leading from the Island to Egmore. The Enemy by these motions were entirely Alarmed, and we had an opportunity of firing many shot at their horse and foot but the Execution was uncertain. About 4 or 5 in the Evening more Cooleys and Bullocks were sent to fetch their Guns, and in spite of our fire carryed them off towards Mr. Turners Garden house where I believe they were left for that night. The Working Party the same Number, and employed, as Yesterday.

The Nabob and his family were last night sent on board the Snow in the Road with Mr. Norris a Councellor, and sail'd this morning for Nagapatam where it is proposed the Nabob shall land, and proceed to Trichinopoly, that he may still have a greater Chance of recovering his Nabobship, and disturbing our Enemy. Mr.

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Lally by a Letter to Count D'Estaing yesterday, complain'd that *Usoff Cawn was committing great devastations to the Southward near Pondichery, and that he shou'd in Consequence be obliged to make reprizals round Madrass. As to that, he cannot well depopulate the Country more than he has, for tho' he may be obliged to retreat it will be long e'er Madrass recovers its Inhabitants, and becomes a place of trade. This Evening two or three boats were seen coming from the Northward, and Landed on the beach of the black Town so that we conclude the Enemy had sent for them to attack the Snow which sail'd in the night.

22nd. Last night the fire of Shot and Shells on the Enemy was as in the preceeding nights. In the Morning, we discovered that they had thrown up some Earth towards forming an Epaulment for the Security of Communication from Pedda Naigues Petta to the Portuguese Church across the Low Ground near the new house begun by Hendrick Smith; that they had barricadoed the Street, North, and West of the old Hospital, and plac'd Guns there; and that they had worked a little at their communication between the breast works. By a Dutch Tappy Peon who had been Siezed and made to work five or six Days with the French, we were informed of their having made several Batterys behind the houses to the North, and West, in so circumstantial a Manner that it appeared very probable; however on considering their situation I am apt to think they are chiefly for their own Security. This Evening about 4 o'Clock a large Vessell was seen to the Northward which at sun Sett being then about 4 Leagues off furld all her Sails but the Fore and Mizen topsails and stood with her head towards the Land; No Colors being discovered leaves us uncertain whether it be a Ship of ours, or a Ship the French say they expect from Mazulipatam with Stores. The Working Party was 100 Men, and employed in General as before, except those on the Demi Bastion where the Traverse being finished, they were set to repair some part of the face, and front, of two Merlons which had fallen down in the late rains.

23rd. The Cannon or Mortars fired last night every ten Minutes on the Enemy in order to disturb their Workmen, who by morning had depened and Lengthen'd their Parallel a few feet. They had also been at Work on their Line of Communication between Mutall Pettah, and Pedda Naigues, but had not finished either that, or the Work they had been on elsewhere. About 8 or 9 in the Morning a Sail appeared to the Northward, and anchored about 11 o'Clock. She Saluted with 9 Guns which we answered with 9 Shot into the black Town. This Ship was the Thames from Vizagapatam in four

* Commander of our black forces to the Southwd. who was ordered to march this Way with 2000 Sipoys and as many horse.

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Days, and brings us advice of Colonel Forde having given the Marquis de Conflans and the French Forces under him an entire defeat; the further particulars of which must be deferr'd till the Letters are landed, the wind blew so fresh, and the surf ran so high, that no boat cou'd get off. However that the Enemy might not wait so long, we had all the troops in the covered Way, and gave them a *feu de Joy* from our Musquetry and three times 7 Twenty four Pounders with Shot into the black Town. The Vessell which appeared last night is still at an anchor 10 or 12 Miles to the Northward, and is concluded to be a Vessell of the Enemys from Mazulipatam with advice probably of their defeat, and perhaps with Stores.

24th. The Wind blowing very hard last night it was apprehended the Thames which had only one Anchor and Cable and drove, wou'd have been obliged to quit the road, however she rode it out, but on seeing the Vessell to the Northward weigh and Stand towards the Road, she weigh'd also, and strucked off to Sea; In the afternoon she attempted to fetch in again, but by the Evening was out of Sight to the Southward. The French Vessell came opposite the North End of the black Town, and anchor'd. The fire of Shott and Shells last night on such Places as the Enemy was suspected to be working at, was some what more frequent than the preceeding Evening. And by what we coud discover they had only enlarged their Parellel a little, and placed a few Timbers within to keep up the Earth. The Working Party was about 100 Men and was employed on the blind before the old N. East Bastion, and in raising the Parapets of the Royal Bastion. The Blacks in facing the Embrasures of the Northern works, and finishing the Traverses of the North Ravelin. This Evening a Soldier was executed for attempting or threatening to Shoot his Serjeant. Finding that the Soldiers on the Working Partys were some what unruly, orders were given out at my request, that all people so employed shou'd strictly obey my own, or Assistants orders, and in case of neglect be severely punished. Mr. Cotsford a Companys Servant was appointed Practitioner, and to rank as Ensign.

25th. The fire from our Cannon and Mortars was kept up last night as in the preceeding. The Enemy as far as we cou'd perceive had done very little work, and that only in deepening and thickening their Parellel. Our Working Party was 100 Men besides some few Lascars, about 30 Cooleys, and 50 or 60 Sepoys. They were in General employed as yesterday except in removing the Fascine Parapet on the Sea Gate Redout, and making another of Gabions. The Traverses of the North Lunette were this Day finished, and the Platforms of the Demi-Bastion were lengthened 8 feet with sleepers and Plank. The Govr. and principal officers having assembled this Evening, and considered some Intelligence they had received of the

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Enemys erecting Batterys, agreed that the most necessary work at present was finishing the Traverses on the Royal Bastion, and then closing the opening between the Northwest Curtain* and the blind before the Mint Sally port. Also erecting a Traverse in the covered Way before the North face of the Royal Bastion. Last night as a Corporal was patroling on the Glacis to the Northward a Sepoy fired at him and shot him dead.† In the forenoon a Sloop appeared to the Northward standing this Way, but the french Ship hoisting her Colors when the Sloop came abreast, and firing two Guns, the Sloop anchor'd, and soon after stood in under the Ships stern. She had white Colors but appeared to be a Moors Sloop.

26th. The fire of our Artillery and Mortars was last Night pretty smart, and we cou'd not perceive that the Enemy had done any thing on the N. East. On the West in the Street going into Pedda Naigues Pettah near the old Hospital we perceived they had placed some green Gabions and made a work, but it appeared to be rather a retrenchment across the Street than a Battery. There was also something very like or actually a piece of heavy Cannon in the Street, at which and an old Wall some Shot were fired to Day, but their effect was not very great. A Small sloop passed by in the offing. The Serjeant who for a long Time had had the Care of the Keys of the Garrison, being sent in the Night to let out a couple of Hircars, took that opportunity to desert, and carryed off the Keys of two Barriers at St. Georges Bridge. He also carryed off 800 Pagodas belonging to a Comrade who had Lodged it in his hands. The Man was generally esteem'd a quiet careful Person, but being nearly detached detected in a concern of Arrack selling, and apprehending Punishment it is imagined was the Cause of his Desertion.

27th. Last night a pretty brisk fire was made from the Cannon and Mortars on the North front, on such Places as it was imagined the Enemy were at work. An Hircar came in from Chinglaput in the night, and brought Letters from Usoff Cawn of the 23rd when he was a Days march from thence with a considerable black force, and expecting to be joined by Major Caillaud every Day. The Enemys Black force it is said are gone to meet him. A Cattamaran also arrived from Pulliacat and brought Letters from the Resident there, advising that he had a Patmar from Bombay. The Working Party was 100 Europeans and 250 Sepoys employed as yesterday.

28th. The fire from our Cannon and Mortars was pretty smart in the night on such places as we imagined the Enemys were at work. In the Morning we discovered that they had thrown up some Earth among the Ruins of the houses a little to the North of

* Vide Plan (f).

† This Accident and some others of the like Nature by means of the Sepoys irregularity prevented a good deal the frequency of Patroles.

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the old hospital, and that they had thickened and heightened their work to the North so much that it had more the appearance of a Battery than Parellel. By some Motions which we observed of the Enemys black Horse from Egmore towards St. Thomá, we concluded the Enemy had advice of Usoff Cawns near approach. A Paddy Boat or Sloop came in from the Northward, and was stopped by the French Ship. The Working Party of 100 Europeans and 300 Sepoys was employed on the Works already mentioned.

29th. The fire of Shot and Shells to the North and West was pretty brisk in the night, however the Enemy had been hard at work, for in the morning we perceived they had form'd a stout Parapet to the Westward, and to appearance had three Embrasures in it tho' they were not opened the Intent seems to be to fire on St. Georges Lunette the Bridge of Communication to it, and the Communication to the Bridge leading to the Island. Their Work to the Northward appeared now very plain to be intended for a Battery in which I observed five rows of Pickets placed at equal Distances as Centers of Embrasures, and by the length of the work there might be room for four more. The Direction seems to be against the North face of the old North East Bastion, and the North face of the Demi Bastion. In the Night Hircars came in from Usoff Cawn acquainting us that he was at Vendalore, and about 10 in the Morning we perceived a Red flag on the Mount instead of the white there before; so that we concluded Usoff Cawn had Possession of that Post. The Enemy this afternoon appeared to be working on their Battery to the Northward, and several pieces of Timber and Plank were seen carrying thither for Platforms. Towards the Evening I also discovered a large Mortar placed on the Communication between the two Breast work first begun by the Enemy near the Sea Side, from which is to be suppos'd they will soon salute us. About Sun Sett a Deserter came in from the Enemys Works to the Northward. The Working Party of Europeans was 100 men and about 300 Sepoys employed as yesterday.

30th. The fire of our Artillery and Mortars was last night pretty brisk, and I believe prevented the Enemy from working much, for I cou'd not perceive any great addition to the Northern Battery. To the Westward I observed they had thrown up a good deal of Earth behind some old Walls which seems to be intended as a Battery to enfilade the North Face of the Royal Bastion, and the covered Way before it, but the form is as yet very incompleat. In the night a boat came from Sadrass and brought some Letters of the 18th from the French Army to Pondichery, which Captain Preston had intercepted. From these we learn that the Enemy lost by our Sally on the 14th about 220 men and 30 officers killed or wounded. In Short they acknowledge themselves to have been thrown into the greatest

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confusion, and that they must have been entirely ruined had our party advanced more regularly on them, and been supported by another body to the Northward. A Letter from one of Mr. Lallys Aid de Camps to the Council at Pondichery complains much for want of money, and desires they wou'd supply him with some, if it be but 100 Rupees and that too chearfully; for their affairs were in a fair Way, and the conquest of Madrass certain. In the Morning we perceived a great smoke at the Mount, from whence we concluded the Nellore with his whole force was there. This was confirm'd by an Hircar coming in at noon with advice that there had been a skirmish and some French Troopers taken. A great Number of black troops horse and foot with large herds of Cattle were observed to come from the Mount and St. Thomé to Egmore; and two Guns were sent from the Black Town thither. Another Deserter came in this afternoon, and in the Evening a flag of Truce with a Letter from Mr. Lally complaining of our firing at his head Quarters and threatening to burn the black Town in return but of this he had no right to complain, because he is the first General perhaps that fixed his head Quarters within point blank Shot of the fort, and Lodged a Regiment, and his Ammunition at the same Place. The Working Party 100 Men and 300 Sepoys, employed as before except on the blind before the old N. East Bastion which was finished yesterday.

31st. Last night and towards the morning particularly the fire from the Cannon and Mortars was rather smarter than before. At Day break a large body of Sepoys, the 1st Company of Grenadiers, and the Troop of Horse went over the barr to the Southward, and into Trivelcane Village where they surprized a small Guard or two of Sipoys, and intercepted several Letters from which we learn that a Frigate was arrived from the Islands to Pondichery, and had brought about 200000 Dollars, but no mention was made of any Force. The going out of our Sepoys gave Mr. Lally the Alarm, so that three or four Picquets of Europeans, and some white horse with Guns were seen marching from the black Town to Egmore. A Party of 40 Europeans and as many Sepoys in 8 Boats were sent off in the night to stretch a Chain out to the Eastward, Lest the Boats to the Southward which had brought the Enemy Ammunition shou'd slip by, and land it to the Northward. Letters came in about 10 in the Evening from Capt. Preston and Usoff Cawn acquainting us that in the morning the Enemy in Number about 1000 black and white under Colonel Kenelly, had about day break advanced four Guns near the Mount, and Cannonaded him, which our people answered so briskly that the French retreated, afterwards they came on with two Guns which our people made a push at and took, killing 15 of the French on the spot and wounding Colonel Kennely, 1 Captain and 25 Men. An Artillery Man and Hussar came in last night or

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this morning. In the Afternoon a large Ship appeared to the Nort East and by Sun Sett was near East of the Fort, with the Hull jus appearing. The French Ship hoisted first English Colors, the french, and fired two Guns; but the other Ship stood on to th Southward, and show'd some Colors which had a white field, perhap Portuguese. The Enemys work to the Northwd. appear'd to hav received no addition this morning, but that to the *Westwar plainly appeared to be design'd for two batterys; one in which thre or four Embrasures were form'd apparently to fire in the Northwes Lunette, and the other of 5 or 6 Embrasures not yet traced to infilad the face of the Royal Bastion, and cover'd Way before it. Th Working Party consisted of 100 Europeans, about 40 Cooleys, 3 Lascars, 10 Pions, the Mestry Bricklayers, and about 60 Sepoy who were all employed on the several Works before mentioned.

* Vide Plan D.E.

(*To be continued*).

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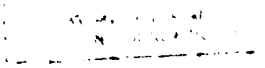

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MEMOIR.

MAJOR-GENERAL ROBERT DUFF.

On 2nd December last, after a short illness, Major-General Robert Duff, R.E., passed away in his 83rd year, at his home in Berkshire. He entered the Corps in 1850, and in 1853 was ordered to the Cape where he served until 1858; and he thus missed the Crimean Campaign and the active service of the Indian Mutiny. The later years of his service, about 25, were passed at home stations.

The name of Capt. Duff will always be remembered by his excellent work in the organization and equipment of the mounted branches of the Corps. Under the late Sir F. Chapman, K.C.B., and Sir Lintorn Simmons, K.C.B., as C.R.E.'s at Aldershot, Duff carried out all the early stages of mounting, equipment, and training of the Pontoon and Telegraph Trains, and worked untiringly for 11 years at Aldershot. The years after the Mutiny were full of Army reorganization, and during his constant attendance at the War Office on Corps business, Capt. Duff became personally acquainted with Lord Hartington, the Under-Secretary of State for War, and gained his confidence to such an extent that he consulted him as to reforms and rearrangement of stores, etc., at Woolwich, and largely adopted his views. Officers of the Corps who served with him at Aldershot in the Train speak in high terms of his exertions both in command and grasp of duty, but they also tell of serious overwork and consequent loss of health.

The reaction that always takes place after war at one time threatened to take the form of reducing the establishment of the R.E. Mounted Branch, and it was only averted by the personal influence of Duff with the Under-Secretary of State for War, always supported by our own officers.

In 1865 Sir L. Simmons as C.R.E. brought forward the "important and meritorious services rendered by Capt. Duff in the formation of the Royal Engineer Train, and the organization of its equipment" for the special notice of H.R.H. the Commander-in-Chief. Reference was also made "to the valuable assistance Capt. Duff has rendered in connection with the Store Department at Woolwich," and the Commander-in-Chief expressed his approbation of his "valuable services." In 1879, as Lieut.-Colonel at Shorncliffe, the

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D.A.G. offered to submit his name for the appointment of Assistant Commandant at Chatham. He had previously declined to work at the War Office as Assistant Director of Works for Barracks. He held the post at Chatham for 2½ years and then retired in 1881 with the rank of Hon. Major-General.

Any appreciation of our brother officer would be inadequate which did not relate his remarkable work in creating the Golf Club at Homburg in the years 1896–99. The task was difficult : the health-seeking visitors could not go far afield for amusement, and Duff, having, with greatest patience and tact, overcome the objections of the local authority and the sensitiveness of the visitors, started with a few putting greens in the park, actually amongst the patients, in 1896–7 : he then devised a miniature links with holes up to 100 yards apart, for iron play only, in the open spaces of the park, and, in 1899, the Club was established with H.R.H. the late Duke of Cambridge as its first president. In 1904 the links were extended from 9 to 18 holes, the fairway being devised, with consummate skill, through gardens and plantations bordering the mineral springs, eventually winning the conviction of all that the only course had been adopted whereby the game could be pursued by those undergoing the Homburg cure which rendered would-be players unfit for the strenuous efforts of the ordinary game, and, at the same time, secured the suffrages of old golfers, so that the Club House became prominently the afternoon tea resort of the English visitors admitted to the Club.

" The Club House (designed and built by Duff as Hon. Secretary) had become recognized as the place at which all who had claims to distinction should meet at least once daily. Royal personages, cabinet ministers, ambassadors, peers, judges, distinguished officers and other lesser lights were constantly to be seen engrossed in play. Eighteen members of ruling Houses accepted membership, among others the Crown Prince of Germany and Prince Henry (the Emperor's brother) who has repeatedly played on the course."—(Memo. by British Consul Frankfort).

The Club prospered from the start and rapidly increased its membership to 2,400, and the Hon. Secretary had the privilege of assisting King Edward VII., the Kaiser, and many other notable visitors in the Royal and ancient game. General Duff resigned the post of Hon. Secretary in 1912 with valuable souvenirs of his tenure of office.

General Duff married in 1866, Beatrice, daughter of the late James Maxse, and granddaughter of the fifth Earl of Berkeley. She survives him. Their only child married F. Sharp, Esq., of Ascot Lodge, only surviving son of John Sharp, of The Wilderness, Lancashire.

W.D.M.

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TRANSCRIPT.

ON AN INDIAN CANAL.

By MAJOR-GENERAL G. K. SCOTT-MONCRIEFF, C.B., C.I.E.

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(*Concluded*).

III.

FROM what has already been said on the subject, I hope it is sufficiently proved that an Indian canal is constructed rather for the benefit of the people than as a commercial concern intended as a source of profit to the State. As, however, there is a class of would-be philanthropists who imagine that all their countrymen in foreign lands are actuated simply by selfish motives and a desire to enrich and aggrandize their own country and their own class at the expense of the natives, it is perhaps desirable to emphasize this matter.

A friend of mine, a skilful and clever irrigation engineer, was dining with one of the pseudo-philanthropists above mentioned, and the conversation turned on the Punjab canal system. My friend mentioned with some satisfaction that the average profit, after all expenses were paid, was generally over 10 per cent. "And does all that money come out of the pockets of the people?" asked his host. "Yes." "Then I wonder you are not ashamed to mention it," was the reply, to the engineer's astonishment. "The idea of extorting such enormous profits out of a half-starved peasantry is absolutely monstrous. The State ought to be quite content with 4 or 5 per cent.," etc., etc. In vain my friend tried to explain that the basis of the whole system was the land revenue, that the State was regarded as the owner of the land (which, by the way, is the Socialist idea), that the tiller of the soil paid to the State the equivalent of a percentage—about one-tenth—of the produce, and that if the State supplied water which increased that yield of produce a hundredfold, the revenue would increase in like proportion. If by economy of design and management, or by the configuration of the ground or any other favourable cause, the cost of providing that water was small, the corresponding gain to the State was large, and *vice versâ*. But it was all in vain. The philanthropist could only grasp the idea—10 per cent. profit out of the pockets of the people; and in his eyes, blinded with prejudice and ignorance, it was iniquitous.

That such was not the opinion of the impoverished people of the country was brought home to me very forcibly one hot weather about the beginning of June, when I was carrying out some works on the left

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or eastern side of the Jhelum, opposite to a little town called Jalalpur, where the Salt Range—a barren range of low hills—comes close to the river. A classic spot this: for here Alexander the Great crossed the river—the ancient Hydaspes—and fought a successful battle against superior numbers. Not far from this place also is the modern battlefield of Chillianwallah. The Salt Range recedes from the river below Jalalpur, leaving a wide and fairly flat space of ground for many miles—a region dotted over with villages and extensively cultivated. The natives of this region had asked for a canal, and I was ordered to examine the country and report whether the matter should be taken up seriously.

I sent my servants and baggage across by a ferry to a little rest-house at Jalalpur, intending to cross myself in the cool of the evening. At sunset I rode to the ferry accordingly, and without any difficulty crossed the first arm of the river, in a clumsy flat-bottomed barge, probably of a pattern that is unchanged since Alexander's day. But the main stream, about half a mile wide, had still to be crossed, and as the boatmen were towing the barge up the margin of a flat island in midstream, a tremendous duststorm came on, and we had to cower in the best way we could while the fury of the storm passed over us, obliterating every object from view, and rendering further crossing impossible while it lasted. As one waited there in miserable and involuntary patience, it was with sad regret that the remembrance of the charms of England in the lovely foliage of early June came to the memory. It was two hours or more before the storm had sufficiently abated for us to attempt to go farther, and by that time night had fallen. With some difficulty the boatmen were persuaded to proceed. Then followed a most exciting voyage over the brown foaming waves, rushing downwards in full flood, for the heat had brought down quantities of melted snow from Kashmir. It was a weird sight to see the almost naked figures of the boatmen silhouetted against the lurid night sky, as they rushed along the gunwales of the clumsy barge, making frantic efforts to push the craft across, the current meanwhile taking us down stream at a racing pace. We got across about ten o'clock, and I found my way to the rest-house, whence after a meal and a few hours' sleep I started, long before daybreak, on horseback to ride over the country on which I had to report. There appeared to be no impossibility in making a canal, and it certainly seemed as if the labour of tilling the soil was largely increased by the saline crust which had been washed off the hills by each rainy season, and which the farmers had been obliged, with infinite labour, to remove. I halted at a village to have a talk with the people, hailing a respectable man who was working there. When I told him my errand he gazed at me for a moment incredulously, then rushed off to gather some of his companions. Then ensued a most extraordinary scene. A crowd of men gathered round me, kissed my feet, grovelled in the dust.

"We have had nine bad harvests in succession," said one, "and if the Sirkar (Government) cannot give us water we must leave the place. It is our land, and our fathers have lived here for generations, but what can we do?"

"But," I said, "you will have to pay a higher land revenue, double what you pay now."

"We would gladly pay that, and far more."

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It was with difficulty I was able to get away from them, and riding back to the little rest-house spent the long hot hours of the day writing a report recommending the carrying out of detailed surveys and investigation of a regular scheme.

Nine successive bad harvests! It was a most pathetic appeal from men who were evidently in sore straits. Yet these men were not absolutely famine-stricken, and it is to these especially that the Indian Irrigation Branch has brought relief. It must be, of course, recognized that there are many places in India where irrigation is, owing to the nature of the ground, impossible. Hence it is sheer nonsense to say, as some ignorant newspapers at home say, that a greater extension of canals would *prevent* famine.

But the more canals there are the more crops are grown, even in times when the rains fail, and the more food is produced in the country generally. Railways can transport that food to the places where it is most needed. Hence canals help to reduce the suffering caused by failure of the rains. Railways can also transport the poor famine-stricken people from a district where they are starving to places where canals are being made, and therefore where work can be found for the necessitous. Such an experiment was tried on a large scale on the Jhelum Canal in one of the recent famines. It ought, perhaps, to be mentioned that in every district there are certain schemes kept ready for the employment of people in case of famine. If possible, these schemes are designed to be of a profitable nature—not merely digging for the sake of doing so, but work which is necessary and useful. It is, however, not always possible to find work for the unemployed and feeble (a difficulty which occurs in other places as well as India); and when, in the case of the Jhelum Canal, it transpired that there was profitable work for thousands of people in a practically uninhabited land, it was evidently a wise course of action to send the people to the place where work on a large scale was in need of unskilled labour. So it happened that one day the executive engineer of the works got a telegram ordering him to expect 30,000 people in a month's time, bidding him report fully how he intended to employ them, ordering him to prepare huts for their accommodation, water for them to drink, tools for them to use, and to arrange with the Deputy Commissioner of the district for depôts of food at suitable positions. All this was done within the specified time, every detail being first fully worked out, estimated, and sanctioned by the local government; then contracts were got out, some 30 or 40 hutted camps built, wells sunk and fitted with the simple apparatus familiar to the people for raising water, depôts of tools and food prepared, and overseers detailed to show the people their tasks. A heavy addition all this to the work of men already fully occupied from dawn to dark, but the Indian official has to learn to work his mental and physical machinery with more than its normal loads, and an extra demand has to be taken as part of the day's work.

In due course the first 10,000 of the army of famine workers arrived in various special trains, were deposited at a little railway station about 15 miles from the scene of their labours, and there rested in a special camp prepared for them close to this station. A poor, disheartened, emaciated mass of humanity, of all ages and sexes, old bent men, withered

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crones, and many little children. It was impossible to separate families, and so all sorts and conditions of men and women had come, with bundles containing their few possessions; a few cooking-pots and rugs, with possibly a beloved water-pipe, constituting, as a rule, the entire family outfit. The leader of this host was a young civil officer, well known a short time before at Harrow and Oxford as a good cricketer. The Deputy Commissioner of the district who received them was, curiously enough, an Eton and Cambridge man. It was on these two young Englishmen that the chief duty of looking after the people devolved.

The newly arrived gangs were drafted off into various working camps, and work was duly commenced, when a dire calamity happened. Cholera broke out. It was clear that they must have brought it somehow with them, for they moved into an uninhabited country; and although the water in the newly made wells tasted somewhat bitter, owing to the malodorous *pilu* wood used in the wells (there being no other wood obtainable), the medical authorities were unanimous in concluding that, whatever the engineers could do, they certainly could not manufacture the cholera bacillus.

Time would fail me to tell how heroically the European officers exerted themselves to allay panic, to segregate and to comfort the sick, and cheer the healthy. The disease was quickly stamped out, but it unfortunately prevented the remaining 20,000, for whom all arrangements had been made, from coming.

But those who had come soon began to flourish. There were, of course, some feeble old people and others too young to work; but for the most part everybody could do something, and there were tasks which could be given even to little children. It involved patience, kind treatment, very hard work, and unremitting attention; but these were not wanting. In addition to the European officers, some native gentlemen of good position volunteered their services, which were gratefully accepted. One of these, for instance, took as his special charge the camp set apart for orphan children, and it was pathetic to see how quickly he gained the affection of these waifs and strays.

When the work was well established it was visited by the highest officials in the province, every head of a department, every important functionary, and many minor satellites, until, as was humorously remarked, "the Bar became like the shield of Achilles, thick with bosses."

After some six or eight months the scarcity passed away, and the people were sent back to their homes, a very different set of creatures from those who had come. Well nourished, healthy, and fit, they were, above all, perfectly satisfied with their treatment. I happened to be at the railway station during the few days when they were being despatched under the superintendence of the two university men above mentioned. The people were warm in their farewell greetings. "When we came," said one, "we were afraid, but now if the Sirkar were to tell us to go with you even to Kabul we would go." The Punjabi peasant regards Afghanistan as the least desirable spot on earth for him to visit, so this was about the highest praise he could give.

It was only one proof among many that I have seen in various places, that the type of man produced by our public school and university system attracts the confidence and even affection of different types of

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humanity all over the world. Sikhs and Gurkhas, Chinese and Africans, all follow men of this class cheerfully into danger and hardship. Apparently no other nation attracts this confidence. The chief reason must be that it is evident to the people that the English *gentleman* has absolutely no axe of his own to grind, and that he acts not for the aggrandisement of himself but solely for the good of the people over whom he rules. Those of his countrymen who fallaciously impute to him other motives display their own ignorance as well as their malevolence.

We have not yet alluded to one large, though as yet hardly touched, asset in these great canals. The development and transmission of power is one of the features of modern engineering science, and the discovery of cheap power is one of the most eagerly sought after demands of modern commercial and industrial life. Our canals have been made primarily to supply water to the land, but in the flow of that water through channels and over falls there is cheap power which, I venture to think, will be in the near future a most valuable national asset. In Kashmir lately a Canadian officer, who has made a special study of such developments in America, and who successfully applied them in Southern India, has recently utilized the waters of the Jhelum to supply power (20,000 horse-power) on a scale hitherto deemed impossible. It may be that the series of falls, for instance, on the main stream of the Bari Doab Canal will be similarly utilized without interfering with its value as an irrigation canal.

At Peshawar there was a scheme, which may by this time be actually carried out, for utilizing the fall in a small canal which flows close to the station. There is a drop of about 50 ft. in a short distance which would supply power enough to light the whole place with electric light,—no small consideration in a spot where the border thief is so much in evidence, and where shooting the sentries is a national pastime among the tribesmen.

The Malakand Pass, a few years ago the scene of much fierce fighting, is now being pierced by a tunnel which will bring the waters of the Swat River to a barren tract to the south of the Pass. The water passing through the tunnel in its fall is capable of generating power sufficient to supply all the industrial needs of the country for miles round.

Mention of the Frontier recalls the fact that there a canal fulfils a function which, happily, is unnecessary elsewhere. It is a peacemaker, it induces men to turn their swords into ploughshares, it gives them some other occupation than highway robbery. The most conspicuous example of this is the Swat River Canal, which irrigates part of the Peshawar Valley. That valley, an almost circular plain about 40 miles in diameter, is divided into two, roughly, equal parts by the Kabul River and its tributary the Swat. The southern part had from ancient times been well watered and fertile ; but the northern part, except for a small strip along the river bed occupied by eight villages, whose lands were always exposed to depredations from the caterans in the neighbouring hills, was a bare and desolate plain. The soil was good enough, and evidence of long bygone prosperity was afforded by the extensive ruins of an old Buddhist monastery which crowns a rocky hill rising abruptly at the eastern side of the plain, ruins of excellent masonry, far superior to anything of Pathan workmanship, and containing sculptures, brought

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to light in excavation, which prove the great advance in civilization that must then have prevailed. To the Pathan, however, such sculptures were anathema, idols which no Moslem could regard with tolerance; and as for the ruins, they formed an excellent quarry for stone, but they served no other useful purpose. Meantime the broad plain at the base of the hill and as far as the eight villages mentioned was a wilderness of thorn and coarse weed, a place that no man cared to cultivate, a battle-ground between two clans, kept in check only by the Corps of Guides at Mardan.

It was, I believe, Sir Henry Durand, Lieutenant-Governor of the Punjab, who was himself an engineer officer, as has been already noted, who first, about 1870, conceived the idea of turning the waters of the Swat River over this wilderness. Not an easy task, for the plain is seamed with ravines, and therefore a canal there is necessarily expensive; but if only it could induce the turbulent rivals to lay down their arms and expend their energy on agriculture instead of mutual quarrels, the cost would be money well laid out. Even if the canal paid no per-centage at all, it would be worth a trial on this ground alone (as a matter of fact, it now pays a very handsome revenue).

So a scheme was prepared, and in due course of time the usual careful estimates were sanctioned and work begun. The haughty Pathan, of course, refused to have anything to do with the actual construction, and when labour for that purpose was imported from the Punjab, the unfortunate men were promptly massacred in cold blood. However, that sanguinary deed brought down prompt punishment in a way that need not be detailed here, and the work of constructing the canal went on under three young engineer officers, all military men, as it was necessary after the above-mentioned massacre to house all workmen in fortified posts along the line of the canal.

It was no easy task. The country was bare and desolate, the nearest railway station 170 miles distant, the people of the country unfriendly, and respectable contractors would hardly come, except at exorbitant rates, to a country with so evil a reputation. The three officers were obliged to go about armed at all times, and with an escort clattering and jingling behind them. Individually and collectively they were threatened, although it may be questioned whether such threats had the slightest effect on their appetite or slumbers. But gradually the people of the land began to see that the white men meant business, and they had better acquiesce in their presence. This was especially the case with the senior subaltern,* a big burly John Bull, who went through the world with a white bull-dog at his heels, and was not disposed to stand any nonsense from the most truculent Pathan that ever breathed. A man of strict justice and strong common-sense, who would fight if need be, with a resolution like that of his faithful canine companion, but with no desire to do so. (He died, I may mention, about ten years later in Burmah, having served with distinction in at least three campaigns, and having gained one brevet and a D.S.O.). So the Pathan gave up the worrying game and let the sahibs alone.

The works were important, demanding considerable engineering skill, and of course all materials had to be locally obtained. The officers

* Lieut. (afterwards Brevet Major) T. P. Cather, D.S.O.

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had to live in small dwellings in the fortified posts above mentioned, where in the summer the heat, unrelieved by any shade or the vestige of any green herb, was terrific. But an occasional week-end spent with the Guides at Mardan gave a little variety and companionship, so that on the whole the life was cheery, though the country was bare and forbidding.

Then the Afghan War broke out. All the engineers on the canal were ordered away, and the work passed into other hands.

A few years ago I revisited that part of the Frontier after some 22 years' absence. I heard that the prosperity of that part of the Peshawar Valley had increased by leaps and bounds, that it was absolutely peaceful, and that the revenue from the canal and the wealth of the country it watered were such that the only regret was that the canal had not been made very much larger.

Much interested, I went one day to the old Buddhist ruins. The hill there was one of the few unaltered landmarks in the country. The road thence from Mardan, in former years a bare and dazzling stretch of drab soil, is now a shady avenue, with a sparkling streamlet flowing alongside. Then came the climb up to the ruins, where I sat and feasted my eyes on the glorious scene below. Far off lay the mountains above the Khyber and the Kohat Pass, with the well-wooded and watered country round Peshawar. That was the same as before. Farther north lay the hills of the Mohmand country, and still farther lay the Malakand Pass and the hills round it, also unchanged. But at my feet lay a beautiful carpet of green waving wheat and barley, stretching for miles to the west and south. The sunlight glinted on a bend of the canal, whose course was clearly traceable by a broad belt of plantation stretching for miles to the mountains, and I was not too far away to hear the musical murmur of the water as it poured over a tiny fall at the head of one of the distributaries. It was a glorious day in early summer, the blue sky overhead was cloudless, and there was every prospect of a splendid harvest. New villages had sprung into existence, and a new generation of tribesmen had been born.

As I gazed, drinking in the lovely scene before me, memories came rushing into my mind of fierce hot nights and days in that very land, when the scorching heat seemed to dry up the very moisture in one's eyeballs, when the shimmer of the desert mirage seemed a mockery, not a prophecy, when the grappling with the difficulties of the work seemed a task almost insuperable, and when the blackguardism of men made success appear more and more hopeless. But there it was—the finished work. To see it with one's eyes was a reward far greater than could be bestowed by rank or ribbons, and I remembered good old Sir Arthur Cotton's words, " Gentlemen, I envy you . . . . . Future generations will bless you." With reverence and humility, too, one realized a new truth in the words, " He shall see of the travail of his soul, and shall be satisfied."

It must be remembered that the above three articles on Indian Canals were published originally in 1908, and that consequently many of the improvements, etc., suggested have been since completed.—Ed., *R.E.J.*

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NOTICES OF MAGAZINES.

REVUE MILITAIRE SUISSE.

January, 1914.

THE BATTLE OF MORAT.

By Max de Diesbach, Colonel of Infantry.—This battle, which took place towards the end of 1476 against one of the foremost military leaders of the day, Duke Charles of Burgundy, is one of the most memorable ever engaged in by the Swiss. A critical examination of the records, undertaken by Dr. Hans Wattelet in 1888, threw doubt on the description of the battle which, till that date, had always been accepted as correct by historians. His view was substantiated, when in 1892 a contemporary account of the battle, written by the Milanese Ambassador, Panigarola, was discovered. In this article the correct account is given.—(*To be continued*).

THE LEWIS AIR-COOLED MACHINE GUN.

By George Westter Tricoche.—This weapon is fully described, and illustrated by photographs and a plate. It is the invention of Colonel Lewis, of the U.S. Army, and has a single barrel, under which is a cylinder connected to the barrel by a small tube near the muzzle, in which slides a piston. On discharge, a small portion of the gases escapes into the cylinder and drives back the piston which actuates all the gear. The piston is then forced forward again by a spring, and as long as pressure is applied to the trigger the action is entirely automatic. The magazine is rotatory, contains 25 rounds, and can be clipped on its pivot above the breech in 2 seconds. The amount of gas escaping into the cylinder is easily regulated, and allows of firing anything from 400 to 750 rounds a minute. The barrel is surrounded by an aluminium radiator, like a 20-pointed star (less two points cut away to make room for the cylinder) in section. It is enclosed in a jacket open at the breech end, which projects beyond the muzzle. The gas escaping at the muzzle draws in air under the jacket round the radiator, thus cooling the barrel, and considerably lessens the recoil. The temperature of the barrel rapidly rises to 330°, but only attains 440° at the end of 1,000 rounds rapid fire, which is hardly ever likely to be required. The total weight is only 26½ lbs. and the gun can be fired from the shoulder. The projection of the jacket quite extinguishes any flash on discharge. The weapon is very simple, there are only 49 pieces, which can be dismantled in 30 seconds by means of the point of a cartridge. Though designed for use by infantry and cavalry it is particularly adapted for use on aeroplanes. A pilot in the U.S. flying about 500 ft. high at a rate of 50 miles an hour, and holding the gun between his knees, placed 45 rounds out of 50 in an oblong 53 ft. by 9 ft.

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Instructions regarding Fieldworks for Use by Infantry.

By Lieut. Decollogny.—This article contains some remarks on the revised issue of the handbook. The teachings of the Russo-Japanese War induced all nations to revise their regulations, and the Swiss instructions were issued in 1912. Stress is laid upon the necessity for entrenching during the attack, but the European nations do not go so far in this direction as the Japanese, possibly for fear that too much attention paid to the spade may check the ardour of the advance. Napoleon's maxim should however be borne in mind "Condemnation of hasty entrenchments encourages a spirit of idleness in the troops."

Objection is taken in a few instances to the wording used, and fault is found with the type section of trench for fire from the sitting position, in that it does not provide sufficient protection; an improved section is suggested. It is laid down that clearing the field of fire and providing range marks are of more importance than the provision of cover. The average distance of obstacles from the firing line in works of defence is prescribed as 50 to 100 metres to avoid damage to them from shells fired at the trench. The Japanese consider that artillery fire has so little effect on obstacles that they should not be more than 30 metres from the firing line, in which position they can be easily defended even on the darkest night. The use of dummy trenches is advocated.—(*To be continued*).

The Revised Infantry Regulations.

By F.F.—The introduction of the new rifle has necessitated a partial revision of the *Infantry Regulations;* advantage has been taken of this to modify the wording of other paragraphs which was open to misconstruction. This article deals with the latter. The changes are of no great importance, except that the duties of commanders of groups in the firing line are more clearly defined. The writer compares these duties with those laid down in the regulations of other nations.

February, 1914.

The Battle of Morat.

This article is concluded. It is of historical interest only.

Machine Guns and Dog Traction.

An account of trials lately made in Belgium of the use of dogs for drawing light vehicles carrying machine guns and their ammunition. The results seem to have been eminently satisfactory, and kennels for a dozen dogs are to be immediately built in the barracks of every infantry regiment, also stud kennels at Beverloo. Several photographs illustrate the article.

Operations of the Servian Army.

By A.—A short outline of the mobilization and strength of the Servian Army, and of the strategic concentration, followed by a statement of the strength and stations of the Turkish Western Army. The operations up to and including the Battle of Kumanovo are then sketched. A general map of Macedonia, and one on a larger scale of the battle, are attached.

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REGULATIONS FOR FIELDWORKS FOR THE USE OF INFANTRY.

This summary of the new issue of the regulations is concluded and deals with :—(6). Points d'Appui.—To economize troops the defence must be organized as a network of strongly-held localities linked up by more lightly-held curtains. When the enemy is involved in the network, the defenders of the localities will operate against his flanks. The localities must therefore command the neighbouring ground and flank the curtains. The troops allotted to them should live in them. As they will draw the artillery fire of the attack they must be freely provided with bombproof cover by the engineers. The adaptation of localities to the ground is illustrated by sketches which also show arrangements for gorge defence and obstacles. (7). Execution of Works.—Rapid progress is stated to depend on judicious division of labour, on precise orders, and vigorous discipline. Profiles should be progressive, so that works can be improved without demolishing what is already constructed. All ranks must thoroughly understand the use of tools and be ready to use them, and the French regulations emphasize the necessity for breaking in the soldier to their use by constant practice. Special instructions are laid down for working under fire and at night. (8). Revetment is generally necessary, and will consist of sods, sandbags or continuous hurdle work.

Part II. contains rules for the application of the principles of field fortification (i.) in attack, and (ii.) in defence. Copious extracts from the regulations of other nations are quoted. Communications and camps are then dealt with. In appendices are given sketches of the defence of a group of buildings, and of a large village, also tables of proof thicknesses of various materials, sizes and numbers of tools carried, etc.

A.R.R.

RIVISTA DI ARTIGLIERIA E GENIO.

December, 1913.

AUTOCARS FOR FORTRESSES.

The substitution of mechanical traction for that by animals is continually taking place both for commercial and military purposes.

A valuable article on this subject appears in the *Artilleristische Monatschefte.*

A consideration of the distances that can be traversed by motors by the small number of quadrupeds that can be assigned to a fortress and by the immense quantities of forage that are necessary for the maintenance shows clearly the value of mechanical traction. The author is evidently not by any means in favour of ancient methods and states that the mechanical traction of field artillery is not only possible, but would have been resorted to had the military administration gone thoroughly into the question.

In fact all the objections to motor artillery are founded on the presupposition that the motors should be built on the same lines as motors

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which we now see constructed for entirely different purposes. Considering that the problem of using motor traction for the field army has remained in a state of somnolence, it is not to be wondered at if the employment of mechanical traction for fortresses has been entirely disregarded.

Fortresses are from a tactical point of view considered superfluous, or at least more or less inconvenient, and questions with reference to them seem always to be considered last.

But fortresses cannot be improvised. If at the last moment the garrison requires to be reinforced, it is possible to throw in troops from the first line, but it is not possible then to improvise armour for the guns, or masonry cemented works for their protection in the positions suggested by the enemy's fire. All this should be ready. Every fortress at the moment of the declaration of war should have at its disposal all arms and material either offensive or defensive.

All forms of defence have their weak points, and this is especially true in fortress warfare. The defence of a fortress is, from the commencement of the attack, subject to difficulties if it is not provided with all the technical advantages that it may be possible to provide.

One of the means for facilitating the defence of a fortress consists in the ample employment of mechanical traction.

Mechanical Traction for the Ordnance.—For all the ordnance in a fortress, armour-protected or otherwise, a rapid means of transfer in all directions should be assured. This can be attained not only by the special construction of the carriage, but also by a systematic preparation of the means of traction. In the great fortresses difficulty is always found in moving the pieces of the reserve artillery, owing to the employment of horses from the park; the change from one front to another is a work of much labour, and the batteries are then only able to come in to action slowly with exhausted horses and tired drivers.

The defence has become more and more difficult and but one resource only remains, viz.:—to oppose to the mobility of the attack a similar mobility of the defence. To-day when automobilism holds so conspicuous a place, there can be no doubt that the satisfactory solution should be in the employment of mechanical traction. This idea has been used only in the entrenched camp at Lisbon, where up to the end of 1904 heavy motor artillery is stated to have been adopted. Mention is made of a train of four pieces or of four caissons coupled together and drawn by a single motor. One point also has to be remembered, that, whilst in warfare in the field account has to be taken of a network of roads in an unknown condition and of artillery that is able to move outside the roads and to overcome obstacles, in the fortresses the roads are not only perfectly known but can be prepared wherever necessary, so that the employment of mechanical traction is facilitated in an extraordinary manner. The tactical advantages are also evident. Suppose, for example, the distance of the works from the town to be about 8 k.m. (which represents the least distance not to expose the city to the fire of the attack), and the diameter of the habitable part of the town to be 10 k.m., to move the reserve artillery from one of the encircling works

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to a position diametrically opposite, the distance to be traversed would be 8+10+8=26 k.m.; drawn by horses this would take about five or six hours, while with mechanical traction and with very limited speed the time would be about a couple of hours. The depth of the column is also less, and there is no anxiety about the exhaustion of the horses or the fatigue of the men. The tactical value of a battery thus moved is much increased.

The question of "motor trains" has not been sufficiently studied. It would be desirable to construct motor trains capable of being used for all kinds of guns and mortars. And it is easy to imagine trains with carriages, which would go a long way towards solving the difficult problem of transport of ammunition. The problem of the initial movements by motor traction of siege artillery for the investment of a place is also interesting. In this case the movement of heavy artillery would have great tactical value, as it would be able to act on one point of a fortress or on another.

Another important circumstance in the adoption of mechanical traction for the reserve artillery has to be considered. Any reduction of animals for the park is very desirable. It is difficult to supply all the horses that are necessary for the needs of a fortress. Every horse or other quadruped is a consumer and requires to be provided daily with about 6 kilogrammes of oats which, for the provisioning of the whole fortress, represents several tons. The motors of course consume benzine, but in comparison with forage rations the calculation is relatively much less.

Mechanical Traction for the Ammunition Wagons.—Generally speaking it is not difficult to provide the ammunition in the first fire positions, as this is supplied from the magazines of the place; when this becomes difficult it is brought from the batteries which are replenished from the rear when circumstances require. During the first period of the artillery strife, owing to the ground of the fortress not being so much swept by the artillery fire as later on, the difficulties of replenishing the ammunition can be easily overcome; and in addition to this only a limited number of pieces are in use and less ammunition is therefore expended. The German regulations lay down that the ammunition for the foot artillery should be distributed in such a manner that it can be sent *rapidly in all directions.* For the transport of ammunition it is especially necessary to have recourse to the "binaries" which should unite the magazines with their corresponding fire positions, and these with the railway network of the fortress. The superiority of fire depends upon the number of pieces, and on the weight of the projectiles fired against the enemy, and to ensure this the essential duty of the defence is to arrange for the greatest possible and most rapid distribution of ammunition in every direction.

The employment of mechanical traction for the artillery and the ammunition furnishes the means.

Armoured Autocars.—One of the characteristic creations of modern military science is the armoured automobile which carries a cannon or a mitrailleuse. It has arisen in consequence of the evolution of aeronavigation. It is required to combine speed with force, and to be able

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to follow rapidly the aerial observer, and compel him by its fire to descend to the earth.

The idea, however, of placing a gun on an armoured carriage designed for rapid motion is, in the author's opinion, erroneous since it diminishes the speed which is its first essential. It is difficult to imagine a tactical situation in which the use of an armoured automobile would play a part ; but even admitting an isolated case, it would scarcely justify the adoption of a special gun.

The defenders of a fortress can oppose to the aerial exploration of the enemy the fire of his guns, but the employment of armoured automobiles in the limited space of a fortress would in the author's opinion be useless.

FRANCE.

Siege Exercises.—A circular from the French War Minister decrees that siege exercises will be carried on at Epinal in 1914. Within a sector of that strong place a methodical development of all siege operations will take place, but there will be no firing with projectiles. The exercises will last from 10 to 12 days, in addition to the days for the movements and concentration of the troops, and for the preparatory works of installation.

The artillery and engineer troops assigned to the siege equipments and parks for the attack, and those assigned for the defence of the place will take part in the exercises, as well as one infantry division ; two infantry regiments stationed at Epinal and Toul and reserve formations ; and one cavalry regiment.

E. T. THACKERAY.

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CORRESPONDENCE.

MASONRY ARCHES.

SIR,

"One of the Average R.E. Officers" may rest assured that, if a masonry or brick arch, and its abutments, conform to Trautwine's empirical rules, it will be safe under the ordinary mechanical transport of the present day, provided that the workmanship and the material of the bridge are sound.

The allowance that should be made in the case of old bridges, with badly built arch rings, decayed stone and perished mortar joints, must be a matter of judgment in each particular case; and in some cases the abutments may be unduly weak; a point not easy to determine by casual inspection.

In case your correspondent does not know Trautwine's rules, I append them.

Yours truly,

"ANOTHER AVERAGE R.E. OFFICER."

The Editor, *R.E. Journal.*

RULES FOR DETERMINING THE PROPORTIONS OF ARCHES AND THEIR ABUTMENTS.

These rules are extracted from *Trautwine's Pocket Book.* Their author makes the following note on them:—

> "Inasmuch as the rules which we give for arches and abutments are entirely novel it may not be amiss to state that they are not altogether empirical, but are based upon accurate drawings and calculations made by the writer of lines of pressure, etc., of arches from 1 to 300-ft. span and of every rise from a semi-circle to $\frac{1}{15}$ of the span. From these drawings he endeavoured to find proportions which, although they might not endure the test of strict criticism, would still apply to all the cases with an accuracy sufficient for ordinary practical purposes."

To find the depth of keystone for first-class stone arches, circular or elliptic.

$$\text{Depth of key in feet} = \frac{\sqrt{\text{rad.} + \text{half span}}}{4} + 0{\cdot}2 \text{ ft.}$$

For second-class work increase $\frac{1}{8}$ part; for brick or fair rubble about $\frac{1}{3}$.

For elliptic arches the radius may be taken as that of a circle which will approximately coincide with the soffit curve.

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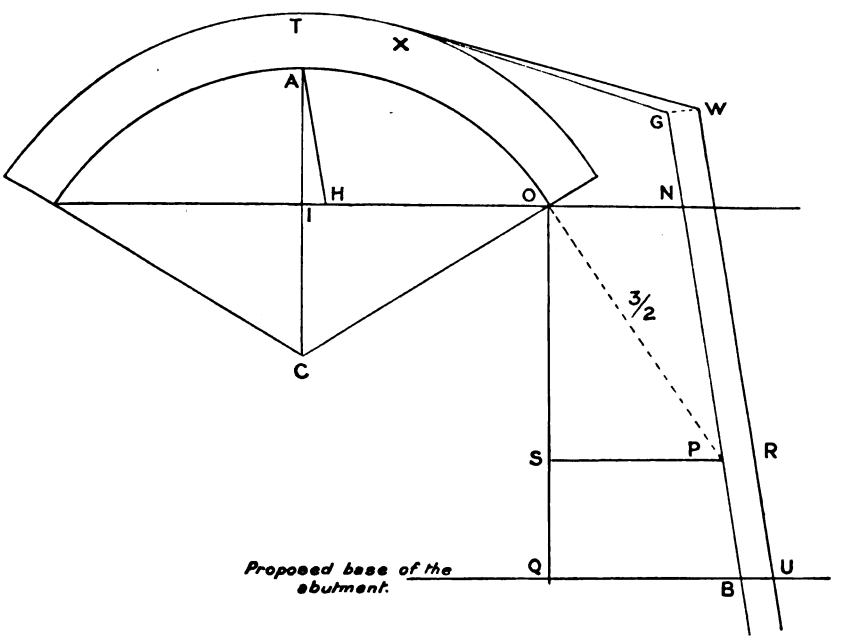
To determine the proportions of abutments.

Thickness ON of abutment at springing $\frac{\text{rad. in ft.}}{5} + \frac{\text{rise in ft.}}{10} + 2$ ft.

Mark the point N thus obtained. From centre of span I lay off IH=$\frac{1}{24}$ span. Join AH. Through N draw GNB parallel to AH. Make GN equal to half the entire height of the arch IT. From G draw tangent GX which will mark the top of the masonry filling.

Through O draw OP at inclination of $\frac{3}{2}$ to the vertical. If P lies below the proposed base (*i.e.*, if the height of abutment does not exceed $1\frac{1}{2}$ times the base) GNB is the back line of the abutment. If not add thickness PR=$\frac{1}{4}$ SQ, and through R draw URW parallel to AH as before. If, after this addition the base QU of the abutment is less than *one-half* its total height (which very rarely happens), then make the base one-half the height and draw a back line parallel to AH as before.

These additional thicknesses are to provide against earth thrusts behind the abutment, rather than against the thrust of the arch, and would not be applied in abutment piers. In abutment piers however appearance has to be considered in deciding their thickness.



All the abutments thus found will be safe, *given good workmanship and materials*, without any dependence on wing walls and no matter how high the embankment extends. If the bridge is so narrow as to bring wing walls close together, so that they will afford material support, the abutments may be made thinner at the discretion of the engineer. Reductions in dimensions however should be made with caution. This method applies equally to the smallest culvert and to the largest bridge, whatever may be the proportions of span and rise, and whatever the method of filling above the arch.

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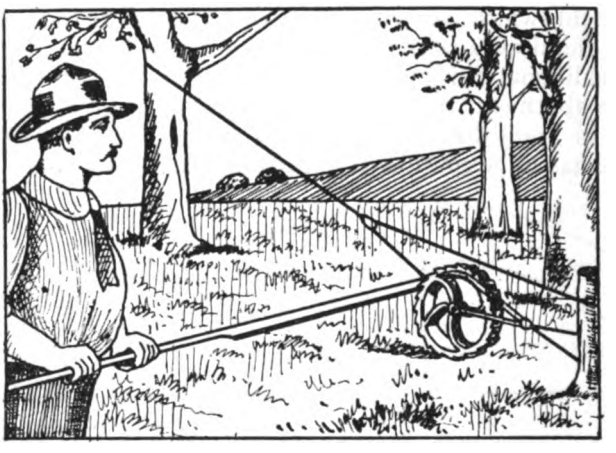
THE "FOREST DEVIL."

SIR,

In the March number of the *Journal* there appears (p. 130) a brief description of the forest devil, together with a plate (p. 131).

On the figures and diagram given, I cannot work out 80* tons pull on the chain from the devil to the tree to be pulled down, if the chain is attached at the root, or within 1 ft. of the ground.

I know another form of forest devil very well, and have used it often in big clearances in Australia. I enclose an advt. sketch of a somewhat similar pattern.



It will be seen that the "pull" is obtained by a combination of lever, capstan, and 2/1 pulley, with the "W" end of the tackle made fast to the pulled tree some 8 or 10 ft. from the ground.

The form I have had to deal with consists of a lever-worked winch, hauling in on the running end of a whip-on-whip, which differs slightly from the enclosed sketch.

Given any ordinary crab winch with a pawl catch, it is easy to rig a forest devil, using something like $\frac{7}{8}$-in. steel wire rope for the main pull, and a bullock chain for anchorage.

Yours faithfully,

CECIL H. FOOTT, *Major*,
Royal Australian Engineers.

R.N. War College, Portsmouth.

The Editor, *R.E. Journal.*

* This was due to a clerical error and the amount was intended for 8 tons.—[ED., *R.E.J.*].

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THE DYNAPHONE.

THE following interesting description of The Dynaphone has been kindly sent us by its inventor, Capt. A. C. Fuller:—

The dynaphone is essentially an instrument for electric telegraphic reception. It is applicable to line or cable telegraphy and to certain systems, *i.e.*,* continuous wave systems, of wireless telegraphy.

Its chief characteristic is its extreme sensitivity combined with its robust construction and small size and weight. The dynaphone is, in effect, a type of electro-dynamic relay which further operates as a signal former, and in itself combines the functions of relay and sounder or other signal former. Before proceeding with a description of the instrument and an explanation of its action a few particulars may be given. The dynaphone produces audible signals with a current of less than 1 micro-ampère.† If it is desired to use a very much larger current, such as is usually employed, say 10 to 20 milli-ampères, no adjustment is necessary; as will be seen later, the only difference is in the enhanced strength of the received signals. The instrument as at present designed is wound with two coils each of one thousand ohms.‡ The winding can of course be varied to suit any special requirements.

The instrument consists of a laminated circular stalloy yoke fitted with narrow pole pieces. These pole pieces are bored to have a circular face. In the gap thus formed between the pole pieces and with the least possible clearance, an armature is caused to revolve. This armature is also laminated and carries a drum winding. The clearance between the armature and the pole pieces is only a few mils. This is in order to maintain the reluctance of the magnetic circuit at a minimum. The ends of the winding are connected to a commutator (or slip-rings for alternating current), and brushes are provided to collect the generated current which is passed through a telephone receiver or recording instrument.

The pole pieces are wound with field coils through which the received signals are passed. The pole pieces are also wound with

* The new type (now under construction) will, it is hoped, prove applicable to all systems of wireless.

† The new one is calculated to be 1,200 times more sensitive and should produce signals with a current of $_{1}^{1}{}_{2} \times 10^{-8}$ ampères.

‡ New one 7,000 ohms.

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a further coil called the controlling coil, connected in series with a variable resistance, a reversing switch, and a dry cell. The use of this dry cell and coil, and the need of the reversing switch will be apparent when the action of the instrument is described.

ACTION.—*Single Current.*—The armature is rotated rapidly by a small independent electric motor controlled for speed by a rheostat. This rotation of the armature gives rise, even with no current in the field coils, to a hum in the telephone receiver. It is found, however, that, by passing a current through the controlling coil and adjusting the rheostat in series with it, this hum can easily be suppressed. If a current now passes through the field coils it is obvious that a magnetic field is formed across the pole pieces. This field is cut by the armature winding, with the result that a pulsating direct current flows through the telephone and of course produces a note in accordance with the number of pulsations per second; *i.e.*, the note is controllable by the speed of rotation. A comparison with the action of a telephone receiver, an extremely sensitive instrument, may not be out of place here.

It will be seen that the magnetic circuit of the dynaphone is the same as that of the telephone receiver. Now in the case of the telephone the lines of force of the magnetic field, in order to produce a signal, have to produce a movement of the diaphragm, *i.e.*, have to do actual physical work. In the case of the dynaphone the lines of force only have to exist, and the armature in cutting them does the work by means of mechanical energy. Hence the dynaphone eventually produces in the telephone in series with its armature, an audible note of any desired pitch by means of an original current of too low a value to produce such a note. It will be noticed that the energy finally available for the signal is greater than that received, owing to the slight electrical energy available being reinforced or augmented by mechanical energy. Hence the dynaphone operates not only as a very sensitive signal former but also as an amplifier.

To Record.—It is obvious that by grouping a series* of dynaphones and running them synchronously, the very minute current passed through the field coils of the first instrument can, by a series of steps from field coils to armature and then to field coils of the next instrument, etc., be amplified to any required value to produce a loud signal or to operate some form of recorder or contact relay.

Double Current.—In the case of double current the instrument is even more satisfactory. The figures quoted in the introduction referred to single current working only. For double current working the rheostat and reversing switch are adjusted so that, with the spacing current flowing through the field coils, there is silence in the telephone with the armature rotating at the required speed. This

* It is hoped that one will now suffice.

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means that the current in the controlling coil produces a magnetic field equal and opposite to that produced by the spacing current; with the result that while the spacing current flows no magnetic lines of force are produced. Thus it is clear that when the transmitting key is depressed and the marking current flows, the magnetic field produced across the pole pieces is that due to the marking current plus that due to the controlling current; *i.e.*, it corresponds to a field that would be produced by a marking current of twice its value, or by the marking and spacing current assisting each other in combination. The result of a field of greater intensity is that the signals also are of far greater intensity.

From the above description of the action it is evident that the instrument takes the place of both relay and sounder, and does away with any need of a local battery. The signals telegraphed are heard in the telephone receiver as short and long buzzes. If desired they can be made of musical pitch by rotating the armature at high speed. There is no necessity to utilize the controlling coil except for double current working unless extreme sensitivity is required.

ADVANTAGES OF THE DYNAPHONE TELEGRAPH RECEIVER.—1. The dynaphone is extremely sensitive and at the same time can work through very severe interference. A current of as little as half a micro-ampère has given legible* signals, and practical working signals for line telegraphy are produced by five micro-ampères.

2. Since the instrument is far more sensitive than any ordinary relay, such relays and the circuits they control can immediately be dispensed with. This renders telegraphy very much simpler and the service very much cheaper to maintain, and does away with many tiresome adjustments.

3. An enormous reduction of battery power follows from the use of the dynaphone. A single dry cell has sent perfect signals through a thousand miles of line.

4. The line may be in a very bad state indeed without rendering work impossible. A light steel wire would suffice in place of the heavy iron or copper wire now in use. A consideration of this shows an enormous saving both in cost of construction and in maintenance. Faults which would render ordinary instruments unworkable would have little effect on the dynaphone, which would continue in action on a line that was far too faulty to work other instruments.

5. Largely increased distances can be worked before translation or relaying becomes necessary.

6. The dynaphone receiver has no moving contact pieces, armatures or levers, and, in fact, requires no mechanical adjustment whatever. Practical men will readily appreciate this advantage.

* These figures are now out of date.

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7. The transmitted signals are received audibly* through a telephone head receiver by the telegraph clerk, in a similar way to wireless signals, though the former are of greater intensity. By this means several clerks may work in close proximity, each only hearing his own signals, and with a complete absence of the din so characteristic of a large telegraph office where the usual pattern of sounder is employed.

8. The dynaphone is not affected in any way by vibration, and is perfectly constant and reliable in action.

Note.—The dynaphone can be used with single or double current and can be worked simplex or duplex.

It can be superposed on an existing telephone line.

The current required to work the dynaphone is so small that no interference is caused to adjacent lines.

WIRELESS.—The dynaphone is very well adapted for use with continuous wave stations.

From the description already given it is clear that continuous oscillations, if rectified by any ordinary detector, will establish a magnetic field across the pole pieces of the instrument for as long as the oscillations endure. The unidirectional pulses produced by the rectification of the oscillations are so rapid as to be rightly regarded as a direct current. This current establishes a field which is cut by the rotating armature with the result that a pure note is produced in the 'phones. This is not a theoretical supposition, but a fact proved by experiment. Hence it follows that by the use of the dynaphone the ordinary wireless detectors are made available for continuous wave reception, as well as for spark telegraphy. Any spark station with the simple addition of a dynaphone can communicate with, and receive messages from, a station using continuous waves as well as with other spark stations.

Wireless signals thus received can be amplified sufficiently to be automatically recorded.

The dynaphone is not affected in any way by vibration, and requires no mechanical adjustment. It is perfectly constant and reliable in action.

ACTUAL TESTS.—1. The dynaphone, even before being perfected, has given legible signals with a current of considerably less than one micro-ampère.

2. Clearly legible signals have been sent on the Post Office overhead wire from Cromer to the G.P.O., London, with a battery power of 1½ volts (one dry cell).

3. A laboratory test was made in which perfect signals were sent with one dry cell through 1,000 miles of aerial line.

4. One coil of a telephone transformer was inserted in the line

* They may be recorded if preferred.

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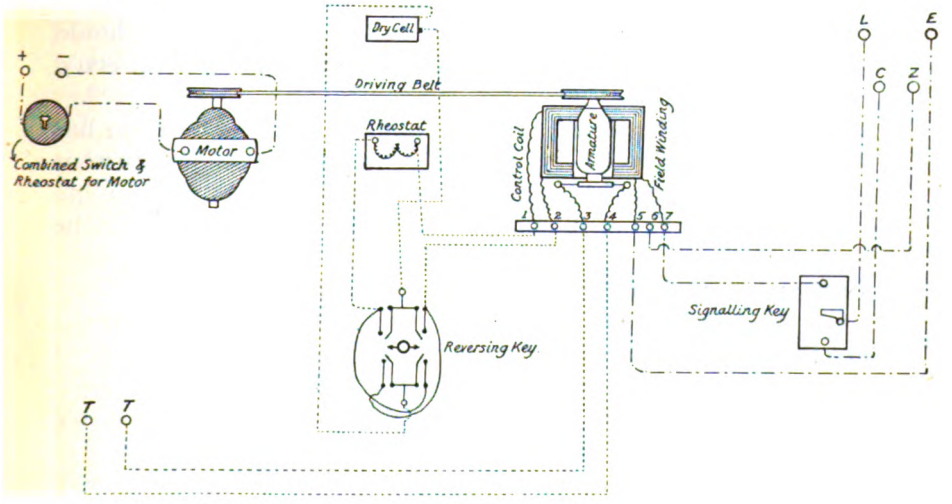
referred to in 3, and the other coil was connected to a buzzer and 4-volt accumulator in series, thus inducing terrific interference on the line. The signals were still perfectly legible with no increase of battery power.

5. One dry cell worked the instrument perfectly through about 200 miles of submarine cable ; with 400 miles the time lag reduced the working speed considerably, though the strength remained ample.

6. Continuous oscillations from a Poulsen arc were rectified by a crystal detector, and produced a perfectly pure note on emerging from the dynaphone.

INSTRUCTIONS FOR USING THE DYNAPHONE ON TELEGRAPH CIRCUITS.—The diagram shows the circuits in the dynaphone. The only connections necessary for telegraphy are to connect the power supply for driving the motor to terminals marked + and —. The telephones to terminals marked T, the line and earth to L and E respectively, and the sending battery to C and Z.

If the instrument is used for reception only, then the leads normally put to relay coils are put to L and E, and no connection to C and Z is required.



DYNAPHONE CIRCUIT DIAGRAM.
1 and 2, Control Coil ; 200 turns.
3 and 4, Armature.
5 and 7, Field Coils ; 80,000 turns.

TO WORK SINGLE CURRENT.—Make necessary connections as above. Start the motor. If the hum in the 'phones is now at all loud adjust rheostat to about 200 ohms and push union switch to left. If the hum is lessened adjust rheostat till silence is produced. If the hum increases push switch to right, *i.e.*, reverse it, and then adjust.

With ordinary strong signals, *i.e.*, using a line current of 10 to 20 micro-ampères or thereabouts it will be found unnecessary to

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use the controlling current at all and the union key may be left in the central position. It is well to work with as much resistance in the controlling circuit as possible to lengthen the life of the dry cell used. The resistance of the controlling coil is only about 2 ohms, hence care must be taken not to leave the union key shut if only a small resistance is in the rheostat. A permanent resistance will be inserted in future models.

TO WORK DOUBLE CURRENT.—Make the necessary connections. Start the motor. Adjust the rheostat and union key so that silence is obtained when the distant key is at rest : *i.e.*, so that the controlling coil creates a field equal and opposite to the field produced by the spacing current : result—no field and silence. The marking current then produces signals. These signals are due to the field produced by the marking current plus the field due to the controlling current, which field is liberated as soon as the marking current replaces the spacing current in the line. In double-current working it is better to arrange so that the spacing current is in the direction to tend to annul the residual magnetism of the dynaphone, thus reducing the controlling current required for silence.

Notes.—The dynaphone never requires more than about 50 micro-ampères for the strongest signals, therefore the working current should not exceed this value. If it does so a resistance should be inserted in the circuit.

It will be noticed that the terminal marked 6 on the diagram has a link to connect it to either 7 or 5. This allows the sending current to traverse the home instrument or not at will. As there is no galvanometer in the set it may be considered desirable to hear the signals going out.

INTERFERENCE.—It is obvious that any direct current that affects the line through leakage, etc., can be obviated by adjustment of the controlling coil. Practically any interference due to high-speed telegraphy, telephony, alternating power circuits, etc., can be completely obviated by shunting the dynaphone with a suitable condenser ; sometimes as much as 6 micro-farads is necessary.

Owing to the design of the dynaphone this simple method will allow the signals to be clearly read in the 'phones, with the elimination of practically all interference. In a few cases the use of impedance coils may still further eliminate any disturbance.

For wireless work the rectified oscillations have to be passed through the field coils of the dynaphone. The dynaphone, therefore, takes the place of the telephones in the detector circuit, and the signals received are read in the telephones in series with the armature.

NOTE.—The instrument has been re-designed since the above was written. The figures given therefore do not nearly represent the sensitivity of the new design which is an enormous advance on the one described above. Owing to delays in manufacture the new instrument has not yet been tested.

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COMPLETION REPORTS ON DURBAR WORKS, P.W.D., DELHI, 1911.

GENERAL REPORT ON DURBAR WORKS, P.W.D., DELHI, 1911.

By MAJOR S. D'A. CROOKSHANK, C.I.E., M.V.O., R.E.

WITH the opening days of the year 1911, the President and certain members of the Central Committee and staff, as then appointed, assembled at Delhi, and commenced on the preliminary survey of the ground, and investigations in connection with the proposed Durbar at which His Majesty King George V., accompanied by Queen Mary, would announce in person his Coronation as King-Emperor.

Proposals were made and schemes considered, and by the 13th January, on which date the Central Committee held their first formal meeting, the Superintendent of Works, P.W.D. (Major S. D'A. Crookshank, R.E., Executive Engineer, P.W.D., U.P.), had drawn up the note which is attached hereto, to outline the general features of possible operations. This note is interesting as a comparison with the scheme actually carried out.

As time went on, the plans matured and estimates were drawn out in detail for each and every work decided on by the Committee, and with the close of the works, the total number of sanctioned estimates which were prepared in the Superintendent's Office amounted to no less than 140.

It will not, however, be necessary to deal with all of these estimates, and only those which were on a large scale will be briefly referred to in the following paragraphs.

1. *Durbar Amphitheatre.*—The Amphitheatre stood out on the Burari Plain on the same site as in 1903 and again in 1877, and comprised two separate stands, both semi-circular in shape, having a common centre. The Durbar Stand proper lay with the back on the South on a radius of 300 ft., and was roofed over 80 ft. deep with 1,57,243 ft. superficial area, providing seating accommodation for about 15,000 persons, including Indian Chiefs, durbaries, officials, distinguished visitors, privileged guests, etc. Screened-off accommodation was specially provided for Indian Purdah ladies of high degree, in eight central blocks standing on the back rows and terreplein of the stand. These blocks were subdivided into 32 compart-

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ments which were screened off and draped so that perfect privacy was afforded. Access to these blocks was given by a porchway on the road at the back, with passage ways which were closed to the view of the public.

Opposite and facing the centre of the semi-circle there was the Royal Shamiana, 60 ft. by 60 ft., of red velvet embroidered with gold and lined with pale yellow silk, in which the Durbar ceremony took place, and on beyond this Shamiana, giving a processional way of nearly 100 yards out to the centre of the semi-circular enclosure, there stood the Throne Pavilion in four terraces ranging up to the Royal Dais, standing at a height of 15 ft. from the ground, which was surmounted by a gilt dome with gold embroidered awning. Open vistas 100 ft. wide stretched out North, East, and West.

The façade of the Durbar Stand and Throne Pavilion were richly ornamented in the Indo-Saracenic style of design in wood and plaster work, painted white, picked out with gold. The other stand having a radius of 900 ft., enclosed the North frontage of the Durbar, and consisted of an uncovered mound in rising tiers providing accommodation for nearly 50,000 spectators, including school children.

Between the Throne Pavilion and this Spectators' Stand there were the Massed Bands and Troops (Regular and Volunteer). In front of the Royal Pavilion on the North vista, stood the Flagstaff flying the Royal Standard, which was made up of two spars, 90 and 60 ft. long respectively, which were supplied from the Bombay Dockyard by the Royal Indian Marine, and erected under the supervision of an officer of that service.

Fire protection and potable water systems were laid on, and there was also a separate canal irrigation channel, but the soil in this locality being impregnated with salts, it became impossible to venture on more than grass borders to the roads and vistas, with alternate plots of palm tubs and flower beds, and some small lawns round the Throne Pavilion.

The Amphitheatre was fed by the broad gauge system and Durbar Light Railway, and by roads converging on it from all sides.

* * * * * *

Communications.—As the roads for the 1903 Durbar were still serviceable, these were repaired and supplemented by new roads for additional access and carriage parking purposes. The main roads were oiled, and the temporary roads watered, so that there was no dust.

2. *Roads.*—The road communications over the Durbar area were in the first instance of a very limited nature, and the few existing miles of narrow metalled roads were soon cut up under the traffic

* The details of the construction of the Amphitheatre will be given in a subsequent report.—[ED., *R.E.J.*]

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of the preliminary measures, so that extensive road construction works had to be undertaken, in the necessity for giving easy inter-access to the central camps crowded into a limited area, and providing for congested traffic and for opening out communication with the outlying camps at a distance.

So that, one way and another, public roads have been constructed to an extent of 40 miles in length, the metalling varying in width from 10 to 40 ft. In addition to this, in order to keep out competition resulting in high rates and retarded delivery, the P.W.D. undertook to supply materials for the construction of the roads in all the camps, which involved very extensive operations and caused considerable trouble and anxiety.

The failure of the rains, although it helped to bring in the supplies of road metal, retarded the actual consolidation of roads, which was further put back by the home strikes interfering with the shipment to time of the special light rollers ordered out.

Construction, however, proceeded satisfactorily, and the public, as well as the camp roads, were all completed and opened to traffic within the month of November, that is, within 8 months of commencement, at an expenditure on public roads of about Rs.4,09,000.

Temporary roads carrying light traffic were, as a rule, made of stone metal which was consolidated with "*kunkur*" screenings or "*bajri*" binding, and this answered the purpose very well. The more important roads had, in addition to a stone soling, a travelling coat of "*kunkur*" metal which gave a smooth clean surface.

The consolidation operations were on a very large scale, and at their height the P.W.D. had 13 steam rollers at work, besides heavy hand rollers and gangs of rammers. Light 6-ton rollers were found most useful and efficient for "*kunkur*" consolidation. The difficulties attending consolidation were considerable, as by that time advance parties and camp supplies were beginning to come in, and as all the roads within the Durbar camps area were either altogether new or up for renewal, it became impossible to arrange traffic routes satisfactorily, and consequently in some cases the new roads got cut up, and in others the public were necessarily inconvenienced by having to make détours.

3. *Dust Prevention. Oiling Roads.*—Delhi being proverbial for dust, the necessity for taking special measures to prevent a reoccurrence of the unpleasant conditions of the 1903 Durbar was recognized, and arrangements were accordingly made with the Asiatic Petroleum Company for the supply of 1,414 tons of liquid fuel from their Budge Budge Depôt, which was spread over the main roads in one or more, but only in a very few cases three coats, which entirely eliminated the dust, and also gave a smooth travelling surface.

Not only were the metalled portions oiled, but the open side-widths, and also in some cases the raised side walks, were so treated.

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The complete success of these operations was very noticeable, and probably much appreciated, and the excellent results fully justified the expenditure of Rs.1,07,141 incurred thereon. Roads not bearing much traffic, and pathways generally, were watered either by cart, or by hand, so that, combined with the camps watering their lawns and roads, there was no appreciable dust anywhere, in spite of the enormous crowds of foot passengers and continuous congested wheel traffic.

4. *Polo, Hockey and Football Grounds.*—The land allotted for this purpose consisted of undulating fields under cultivation, and it became necessary to level off for three full-sized Polo grounds, each occupying a space 1,000 ft. long by 600 ft. wide, and to provide raised seating accommodation, separately for subscribing members and for the general public, to overlook each of the three grounds. The stands for the Polo grounds lay back to back between the two grounds facing out both sides, and seated 9,000 persons on one side and 7,000 on the other. On this double stand there was a tastefully decorated and furnished Royal Pavilion in the centre with pavilions for members at either end. In between there were sunk gardens with fountains, flower beds and summer houses, and crossed by rustic bridges to give communication from one stand to the other. Opposite the end ground there was a stand for the musicians of the Massed Bands constructed crescent shaped, and large enough to accommodate non-subscribing spectators at each end.

The third ground had a separate stand again, and this ground was reserved for the Hockey and Football matches.

Banks were also made at the ends of all three grounds from which casual spectators could view the matches.

Canal irrigation water courses were laid on to all of the grounds, any of which could be flooded over within a period of 12 hours.

Turfing being impracticable in this part of India, the grass was rooted in by hand all over the grounds and stands, and it took very well considering the failure of the monsoon rains at and round about Delhi.

The expenditure of Rs.1,15,518 on the grounds, pavilions, and stands was more than recovered on entrance fees and subscriptions.

The Royal and Members' Pavilions were designed in the English cottage style, with half-timbered walls and red tile roofs. These pavilions comprised complete refreshment buffets, cloak rooms for ladies and gentlemen, kitchens and store rooms. In addition there were retiring room tents dotted about at convenient places on the grounds. A bakery was provided to meet the heavy demands for cakes and bread for afternoon teas, and a large closed shed was erected as a godown for the mowing machines and garden tools.

A stock of chairs and movable benches was kept on the main stand for ordinary requirements, and these were supplemented by bringing chairs from the Durbar stock whenever there was a large attendance.

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The preparation and upkeep of the grounds and flower beds was, for the most part, carried out by the large party of "*malics*" from the Palace Gardens at Gwalior, whose services were very kindly lent by H.H. the Maharaja Scindia.

5. *Electric Installation.*—The Power House, comprising an Engine Room, 35 ft. by 145 ft., and a Boiler Shed, 45 ft. by 145 ft., was made for the P.W.D. by Messrs. Jessop & Co., and is a good example of what excellent work can be done in structural iron work in quick time at their Calcutta shops.

Painted light buff and red outside, and silver-grey and white inside, with its fine display of machinery and fittings, this building was one of the most prominent features of the works undertaken specially in connection with the Durbar.

The remaining buildings in the Power House were provided and erected by the P.W.D., and the settings of the Engines, Boilers and tall steel chimney, the construction of a large circulation tank and other masonry work, was also carried out by that Department.

6. *Review Grounds.*—Here the operations comprised the construction of a central stand for Royalty, and a couple of hundred members of the suites and guests. Combined therewith were provided special retiring rooms for Their Majesties, with large arrival and refreshment shamianas.

The Royal Box was flanked on either side by two covered stands each seating 7,000 persons, and beyond that again by open stands accommodating 6,400 spectators.

Besides these five stands there was a small outlying stand for Warrant and Non-Commissioned Officers and their families, and a large enclosure was made where Indian ladies in purdah could view the proceedings from the privacy of their own conveyances.

All along the frontage of the main stands a lawn was laid, and the Royal Pavilion was enclosed and laid out with lawns and flower beds.

Special road communications were given both for the regulation of the traffic approaching from all sides, and for the sorting out of spectators on arrival, and disposal of empty vehicles.

Water and electric light were laid on.

7. *Central Telegraph Office.*—The Combined Telegraph Office and Telephone Exchange were placed between the Government of India and Press Camps, in order to occupy the most convenient position possible. It was constructed on semi-permanent lines, so as to provide a substantial building for the work of the Department to be carried on in comfort for a considerable time both before and after the Durbar, and it comprised a large central instrument room surrounded by side rooms for the supplementary work. The building was finished off in white with ornamental parapets, quoined pillars,

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and patterned horizontal courses, and had a red tiled roof which was afterwards also painted white. The frontage was laid out in lawns, with a wall and gateposts in keeping with the main building.

A Mess house for the European Signallers was provided on similar lines, complete with out-offices.

8. *Central Market.*—The P.W.D. undertook the designs and construction of the Central Market, consisting of three separate sheds for dry foods, vegetables, and meats, respectively. In order to do all that was possible to keep out the flies, the meat, poultry and fish shed was specially enclosed with gauze wire, each of the 16 stalls separately in itself, and again on all the outside openings of the building. The vegetable shed was also so fitted on all the outside openings. Both of these sheds were efficiently drained and adequately ventilated, and the premises generally were surface drained and enclosed, and finished off completely with communications, electric light, and water.

9. *Reception Pavilion on Ridge.*—This stood on the State Entry Route on the crest of the Ridge near the Chauburji Mosque. It was circular in design having an interior radius of 105 ft., and exterior of 142 ft., with the road running through the centre of it. About 4,000 under-cover seats were provided, and the open space in the centre was utilized by the special representatives of the British India community, who presented an address of welcome to Their Majesties on their arrival within the arena.

Without having pretence to any merit of design or construction, the circular shed, decorated in red and white, with its lawns, red paths, white railings, ornamental façade, pennons and floral features, made a smart and neat enclosed pavilion.

10. *Post Offices, etc.*—For the Postal Department, lines were built for the mail vans and ponies, and for the staff. Also the small red and white striped Branch Postal kiosks and Telephone call stations, six in number, which were dotted about within the central area for the convenience of the camps and facility of disposal of business.

11. *Hospitals.*—Hospital accommodation for natives and the temporary treatment of cases, was supplied in a large central Hospital for 24 beds, supplemented by four outlying dispensaries and treatment depôts. These were built on inexpensive lines, as they were only of a purely temporary nature.

An extensive Conservancy Depôt was also provided for the storage of plant, and parking of carts and tumbrils.

12. *Triumphal Arch.*—A fine Triumphal Arch, in the Indo-Saracenic style of architecture, was constructed in elaborate detail from designs prepared in the office of the Superintendent of Works. This arch stood on the return Processional Route from the Durbar, *viâ* the Princes' Road, at the entrance to the Government Central

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Camps, where it commanded a good view from both sides, and both by day, and by night, when it was lit up with hidden electric lights, it presented an imposing and highly effective appearance.

13. *Stand at Town Hall.*—The P.W.D. also constructed four large stands, accommodating in all 1,860 persons, opposite the Town Hall in the Chandni Chawk, to view the State Entry. In these stands seats were reserved on payment, for Europeans and Indians alike, whose position required special attention on the part of the Durbar authorities. Indian ladies in purdah were provided for in a screened enclosure on the roof of the Town Hall itself.

14. *Camp Works.*—The Officers-in-Charge of the Camps mostly carried out their own works, referring only on occasion to the Superintendent, Durbar Works, for information and the loan of tools and plant, but they had been invited to indent on him for the supply of road materials, and 83 camps took advantage of this, no less than 11,55,000 cubic ft. of road metal of sorts being supplied by his agency, at a cost amounting to Rs.1,60,227.

In order to ensure uniformity and avoid delays, the Superintendent carried out, at their expense, the erection of wire fencing on the frontages of the Camps lying on the Processional Routes, and constructed the drainage culverts on the entrance roads.

In the case of the King's Camp, the P.W.D. not only provided the road materials, but also consolidated the camp roads amounting to 2,21,075 cubic ft., and within the Royal Pavilion the Superintendent of Works undertook the construction of the whole of the staging for the Investiture, and provided the daises required on that occasion, and for the receptions held by Their Majesties.

The only other Camp having a call on the direct services of the P.W.D. was that of the Foreign Office and Durbar Administration, and here the Superintendent constructed the roads, kitchens, motor and carriage sheds, stables, etc.

15. *Miscellaneous Works.*—Many other jobs, such as the complete overhauling and decorating of Curzon House as a Visitors' Camp; the construction and renewal of bridges; the erection of a large Ticket Office; the erection of temporary structures for works purposes and accommodation of labourers; the collection of 17,000 chairs, and construction of 765 benches, required in connection with the seating arrangements for all the functions; and innumerable minor works here and there, have been carried out through the agency of the Public Works Department, by the Superintendent, Durbar Works, and his staff.

16. *Accounts.*—The following statement is an abstract of the expenditure incurred on the several groups of works carried out by the Public Works Department :—

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STATEMENT OF COST.

Item No.	Name of Group.	Estimated Cost.	Actual Expenditure.	Recoveries.	Remarks.
1	Durbar Amphitheatre	5,60,599	5,82,879	89,545	The recoveries were made by sales and transfers to Temporary Works, Delhi.
2	Roads	4,15,240	4,10,298	2,789	
3	Oiling Roads ..	1,28,557	1,07,141	229	
4	The Polo Grounds ..	1,18,520	1,15,518	8,837	
5	Electric Installation ..	1,00,000	1,08,422	35,022	
6	Review Grounds ..	68,863	59,534	12,823	
7	Central Telegraph Office	40,467	36,956	17,079	
8	Central Market ..	38,714	35,038	11,732	
9	Reception Pavilion on Ridge	23,280	22,554	3,279	
10	Post Office Works—				
	*Postal Kiosks ..	10,612	11,267	..	
	Temporary Sheds for Ponies, etc. ..	14,534	14,645	5,770	
11	Hospitals—				
	Hospital Buildings ..	14,577	15,023	1,500	
	Conservancy Depôt ..	955	1,044	..	
12	Triumphal Arch ..	10,000	10,433	..	
13	Stand at Town Hall ..	9,500	10,032	3,272	
14	Camp Works ..	2,55,908	2,61,748	17,667	
15	Miscellaneous Works..	2,00,054	1,96,814	48,371	
16	Minor Works ..	8,076	8,824	..	
17	Establishment ..	1,12,917	1,12,917	408	
	Totals ..	21,31,373	21.21,087	2,58,320	

* Left standing.

Against this total outlay of Rs.21,21,087 on works, there is an expenditure of Rs.1,12,917 on the establishment, permanent as well as temporary, which was entertained for the execution of these P.W.D. Durbar Works, and includes the salary and all allowances of the whole staff of Officers, Accounts and Routine Clerks, and Subordinates, other than the temporary hands such as Sub-Overseers, Mistries, Jamadars, etc., who were charged off to the works on which they were employed for the time being. The extremely low percentage of 5·3 of establishment to works is very exceptional for operations of this magnitude which have been carried out in great detail and working against time under adverse circumstances.

The accounts were from the first entirely kept directly in the hands of the Superintendent of Works, on the lines of a P.W.D. Division on a large scale, the actual disbursements being made, for road works by the Assistant Superintendent, and on all other heads

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by the Superintendent himself. This procedure was adopted in order to ensure direct control over the expenditure, and immediate disposal of bills and payments, so that at all times a careful scrutiny and check was exercised, and the large number of contractors employed, who were mostly men in a small way of business, were kept paid up and in funds to carry on their works without dragging and having to borrow at exorbitant rates of interest from outside sources. As may well be imagined, having to deal with a very large expenditure mostly in small sums at frequent intervals added immensely to the work of the Superintendent and his office, but the results gained were more than commensurate, as delays of any sort would have rendered it not only quite impossible to carry out such extensive works in such a very limited space of time as eight months, but also to keep such a close watch on all outgoings as to be able to work in so well with estimates as the foregoing figures go to show.

From the outset of operations estimates were taken out in full detail for every work, however small, which it was intended to carry out, and this accounted for the preparation of a total number of 250 estimates in the Superintendent's Office. Onerous as this was during a period of high pressure, when immediate commencement and rushing on with works were a necessity, the advantages from the financial point of view, and for purposes of check and compilation of accounts, are obvious, and the time and trouble spent were highly advantageous in the long run.

The usual P.W.D. procedure as regards the disposal of these estimates was, however, not adhered to in this case, as estimates for all works, small or large, were dealt with by the Central Committee, and the Superintendent of Works was not allowed to exercise any of his usual powers of sanction. Work was not ordinarily allowed to be put in hand until formal sanction to the estimate was received, but subsequently in order to save time in carrying out urgent minor works ordered, the Superintendent was given a reserve of Rs.5,000 and allowed to sanction estimates not exceeding Rs.500 within that limit.

17. *Carriage.*—The item which probably caused most trouble was the carriage by road. A lean fodder year further reduced the supply of country carts which was at the best of time unsatisfactory, and consequently the cartmen made extortionate demands and did very inadequate work. This had been anticipated and the purchase of steam lorries recommended, and the single one sanctioned, a 3-ton Sentinel, more than justified its cost by doing continuous rapid work and selling well at the end of operations. A second lorry was obtained on loan, but being out of order very little work was got out of it. These efforts were not enough to stem the tide of rising carriage difficulties, and had it not been for the checking influence of the liberal use from an early stage of the Military and Imperial Service

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Transport carts, the trouble experienced and expense entailed would have been most serious.

Other than the Light Railway system and a few lorries, there was no use of mechanical transport about the camps, as there were no defined lines of traffic on which monorail or motor services could with advantage be established, and there were the objections to having such services feeding in all directions with roads and water and electric systems under construction, camps being erected, and lawns laid down, and no surplus space available anywhere.

The value of the assistance to Durbar Works afforded by the broad gauge railways may be fathomed by their having brought in a matter of six lakhs of cubic ft. of "*kunkur*" alone, besides large quantities of other materials, tools, plant, etc. The arrangements made by the Traffic Departments of the Durbar Railways and East Indian Railway in the carriage of materials and liquid fuel for the P.W.D. were most prompt and efficient, and the special rates allowed were a concession which effected a considerable saving to Durbar funds.

18. *Contractors.*—With the opening of works by the P.W.D., and in the camps, contractors came pouring in from all sides, which was very opportune as the Delhi contractors having been altogether spoilt by the high rates prevailing under the operations for the previous Durbar, and by the conditions obtaining in the local market, anticipated a golden harvest and were practically impossible to deal with. Calling for tenders in the usual way was not at first productive of any useful result, as the local contractors had combined to create abnormal conditions and keep up the rates. As time went on, however, outside competition regulated the supply and reduced rates to very reasonable terms, so much so that with the rising prices it is doubtful whether any contractors, who did not happen to secure any particularly remunerative jobs, made more than a permissible profit, and some, no doubt, lost on their transactions.

The following contractors, amongst many others, carried out works on a more or less extensive scale for P.W.D. :—

No.	Name of Contractor.	Resident of	Nature of Work Done.
1	Messrs. Jessop & Co. ..	Calcutta.	Construction and erection of iron work of Amphitheatre, Throne Pavilion, Power House, etc.
2	Messrs. Balmer Lawrie & Co.	Do.	Supply of roofing sheets, cement and steam lorry.
3	Messrs. Main & Co. ..	Do.	Structural iron work Royal Box at Review Ground and Office Shed.
4	Messrs. Bird & Co. ..	Do.	Supply of timber and matting.

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No.	Name of Contractor.	Resident of	Nature of Work Done.
5	Messrs. Thomson & Co. ..	Calcutta.	Supply of miscellaneous hardware.
6	Asiatic Petroleum Co., Ltd.	Do.	Supply of crude oil for roads.
7	Shalimar Paint Co., Ltd. ..	Do.	Supply of Paint.
8	Lucknow Iron Works & Co.	Lucknow.	Do. Structural iron work for Market sheds.
9	Messrs. Burn & Co. ..	Raneegunj.	Supply of roofing tiles.
10	Perfect Pottery Co. ..	Jubbalpore.	Do. Fire bricks and clay.
11	Messrs. Fowler & Co. ..	Bombay.	Supply of steam road roller.
12	Messrs. Turner Hoare & Co.	Do.	Do. do.
13	Messrs. Muraglia & Co. ..	Do.	Supply of Marble.
14	Messrs. Richardson & Crudas	Do.	Estimates for sanitary disposal.
15	Messrs. Greaves, Cotton & Co.	Do.	Supply of Pumps.
16	Hill Forest Supply Co. ..	Cawnpore.	Do. Timber.
17	Empire Engineering Co. ..	Do.	Do. Water carts.
18	The Muir Mill Co. ..	Do.	Do. Shamianas.
19	R.S.S. Narain Singh. ..	Patiala.	Constructions of roads, Amphitheatre and Polo Grounds and other buildings, etc.
20	Messrs. Tansey & Co. ..	Do.	Miscellaneous iron work.

19. *Rates and Prices.*—But for the precaution taken to concentrate as much as possible all the collection of road materials in the hands of the central agency of the Superintendent, Durbar Works, there is no doubt that not only would the rates for "*kunkur*," "*bajri*," and stone ballast have risen to a fabulous height, and most inferior quality brought on to the market, but the supplies would never have reached the full amount of the demands, and it was only by very extensive dealings far afield, and the ready co-operation of the railway authorities, that the rates were regulated, a uniformly good quality supplied, and the indents complied with. As it was, with a central supply agency, there was an average rise in the rate of road materials of 25 per cent. only, and very superior materials were supplied, whereas in 1903, when camps were making their own arrangements independent of the Superintendent of Works, the rates for a most inferior class of materials rose nearly 200 per cent.

In the case of timber it was only towards the end of operations that the rates for planks and scantlings rose with the denuded stock of sleepers available locally and near by.

There was little or no fluctuation in iron work, as the requirements

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in this line mostly came in from the seaports, and Delhi has in itself very large supplies and extensive dealings in iron of all sorts.

Camp commodities generally, such as tents, furniture, etc., did not come within the scope of Durbar Works, but here again, except that there was an all-round rise in the price of cotton at home and abroad which affected the Indian market as well, it is doubtful whether the demands on account of Durbar made much appreciable difference in the rates and supplies.

The following is a statement which gives a comparison of the rates and prices of labour and materials at normal before, and during the height of, the Durbar operations :—

Item No.	Name of Material or Labour.	Normal Rate before Durbar. Rs. A. P.	Per	Rate during Durbar. Rs. A. P.	Per	Remarks
	MATERIALS.					
1	1st class bricks at site ..	12 8 0	o/oo	16 0 0	o/oo	
2	Kunkar lime ,, ,, ..	25 0 0	%	28 0 0	%	
2A	Do. stone lime slaked at site	0 9 0	c. ft.	0 12 0	c. ft.	
3	Sand at site	4 0 0	%	6 0 0	%	
4	Bajri ,, ...	9 0 0	%	12 0 0	%	
5	Kunkar metal	11 0 0	%	13 0 0	%	
6	Stone metal 1½ in. at site ..	7 0 0	%	10 0 0	%	
7	Do. 2½ in. Do. ..	6 0 0	%	8 0 0	%	
8	Chir wood	1 2 0	c. ft.	1 6 0	c. ft.	
9	Do. in 1-in. planks ..	1 3 0	c. ft.	1 8 0	c. ft.	
10	Iron work	10 0 0	md.	12 0 0	md.	
11	Brick Ballast 2 in. at site	10 0 0	%	14 0 0	%	
12	Surkhi, 1st class, screened	15 0 0	%	20 0 0	%	
13	Country tiles	4 0 0	%	6 0 0	%	
14	Ballies 4 to 6-in. diameter	0 0 9	r. ft.	0 1 0	r. ft.	
15	Grass for thatching ..	10 0 0	o/oo	13 0 0	o/oo	
						Poolas
	LABOUR.					
1	Beldars	0 6 0	diem	0 8 0	diem	
2	Coolies, male	0 5 0	,,	0 7 0	,,	
3	Coolies, female	0 3 6	,,	0 5 0	,,	
4	Carts	2 0 0	,,	3 0 0	,,	
5	Carpenters	1 0 0	,,	1 4 0	,,	
6	Blacksmiths	0 14 0	,,	1 4 0	,,	
7	Masons	0 12 0	,,	1 2 0	,,	
8	Bandhani	0 10 0	,,	0 13 0	,,	
9	Stone Cutters	0 12 0	,,	1 0 0	,,	
10	Iron Mistries	1 0 0	,,	1 8 0	,,	
11	Thatcher	0 10 0	,,	0 12 0	,,	
12	Painters	0 10 0	,,	0 14 0	,,	
13	Bullock pair with driver ..	1 4 0	,,	1 12 0	,,	
14	Bhisti	0 6 0	,,	0 8 0	,,	

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A NARRATIVE OF THE SEVERAL TRANSACTIONS OF THE FRENCH IN THEIR ATTACK OF FORT ST. GEORGE, AND OF THE GARRISON IN THE DEFENCE OF THAT PLACE. ANNO 1758 *AND* 1759.

(*Continued*).

1759. January 1st. Last night about 10 o'Clock came in 2 Deserters and informed us that Mr. Lally propos'd to usher in the New Year by a bombardment, however the Night and Morning pass'd without any fire but what was on our side. The Enemy having made large Detachments to oppose Usoff Cawn was the Reason I suppose of their working very little last night, for I cou'd not perceive in the morning any Material Alteration in their works to the North or West. Letters last night from Sadrass inform'd us that a Moors Vessell from the Nicobars to Porta Nova brought advice of 12 English Ships being at those Islands, and ready to sail for this place. The Ship which appd. in the offing was from Macao, had touch'd at Masulipatam where a Ship of ours (the Hardwicke) prevented her from selling any thing, so that she intends to break bulk at Nagapatam, and come up the Coast. Usoff Cawn we hear has left the Mount, and is gone to Trivambore about a league South of St. Thomé; and the French apprehensive of that Post have sent all their black Troops from Egmore, and a strong body of Europeans to support them. The working Party was 100 Europeans, 100 Sepoys and the same Cooleys and Lascars as mentioned yesterday. They were employed as before except in making Traverses before the Magazine Doors of the Nabobs Bastion.

2nd. Our Fire of Artillery and Mortars was last night very brisk, but to our surprize as soon as the light appeared the Enemy began to fire from four or five pieces of Cannon on the Western Battery (D)* and 1 Mortar, they also threw 12 Inch Shells from four or five large Mortars placed near the West End of their Battery (C) to the Northward. This early Salute some-what astonished us, but as we had 10 or 12 heavy Cannon which bore on the Enemys battery to the Westward, two of their Guns were soon knocked to Pieces and their Merlons so much damaged that they with drew their Guns before Eight o'Clock. From their Mortars they threw Shells till past 7 at night generally four in a flight which were in general aim'd at the Fort House, and so well thrown that 2 fell on the top, and pierc'd the first and second Roofs, many others fell within the square, and

* See Map issued with May No. *R.E.J.*

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ruin'd some of the Rooms. Other houses were also much damaged, but what is remarkable is that not one European or Sepoy was wounded by Shot or Shell nor any other person hurt but a Dubash and Child or two. By Letters from Captain Preston, and five Deserters which came to us in the Evening we learnt that early in the Morning Monsr. Soupire Mgr. General who commanded at St. Thomé had marched a strong body and attack'd him, and Usoff Cawn who lay near Trevambore, in three Divisions. That the Enemy had put our first Division in some disorder taken their 2 Guns and some Prisoners, but that the broken Troops having join'd the second Division fell on the Enemy in Turn and put them to flight killing about 50 Europeans on the spot with two Officers, and if we may believe the Deserters, the Troop of Mr. Aumont was very roughly handled, a Troop of Hussars cut to pieces, and three Companys of Grenadiers greatly disorder'd. Our Guns and Prisoners were retaken. It was to favour this attack of Monsr. Soupiré's that the Enemy begun their fire earlier by some Days than they wou'd otherwise have done, to with draw our Attention from what pass'd to the Southward. We had advice to day that Monsr. La Tour under Pretence of a visit in marching from Pondichery this Way had siez'd on Sadrass, and put a Garrison therein, and that Mr. Lally had given orders for the same finesse to be practised on Pulli-cat. His designs on these Places was the reason we suppose that in a Passport granted some of our Ladys he excepted their going to Pulliacat or Sadrass. However three Boats with several Ladys in them were sent off to Sadrass without Passports before this news arriv'd, so that we fear they will all be siez'd.

3rd. Last night we threw many Shells and fired some Shot at the Enemys works, but they fired neither after Eight oClock. In the morning we observed they had closed up the Embrasures of their Western Battery which was much disorder'd by our Cannon. They had also added something in height and thickness to their Northern Battery, but fired not from either, Cannon or Mortars. We observed this Day about 60 or 70 European Horse returning in a straggling Manner from the Southward towards the black Town, and among them 30 or 40 led horses which we imagine lost their Riders in the Action yesterday against Usoff Cawn. In the evening a small Vessell appeared to the Northward for which we hung out Lights at the Flag staff. The working Party was 100 Men and about 200 Sepoys, who were employed in finishing the work across the Gut to the Northward in making Traverses before the Doors of the Nabobs Bastion, and across the streets leading to the South Curtain where the Guards are in future to parade.

4th. Our Artillery and Mortars kept a brisk fire last night on the Enemys Batterys, but neither Shell nor Shot was returned from them. However in the morning I observed they had opened the

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Epaulment of their Northern Battery and let in Fascines for the Facing of the Embrasures; they also had repaired part of the Western Battery, and show'd two Guns in the Morning but on our firing a few Shot they were with drawn, and the Embrasures choaked with fascines. The Vessell which appeared last night was not to be seen in the Morning. Yesterday I drew out the following Instructions for my Assistants, dividing them into two reliefs, and this morning Mr. Leigh and Cotsford went on Duty to be relieved by Lieut. Eiser and Stevenson to morrow. The working Party was 100 Men and 250 Sepoys employed as yesterday. Enter the Instructions at length.

5th. Our Artillery and Mortars fired pretty briskly last night on the Enemys Batterys, but they neither fired Shot, nor Shell in the night, or to Day. They were not idle however but finished the facing and almost opened 7 Embrasures on their Northern Battery where I perceived 3 Guns in the Evening, and in the morning 3 in the West Battery which were soon masked or removed. On the whole there is great reason to believe the Enemy will open their Batterys on us to morrow morning, at least nothing but the want of Ammunition seems to hinder it. Unless we are lucky enough with our Shells to destroy some of their Guns and Platforms in the night, by an explosion or two which we perceived in the Day there is reason to believe some Ammunition or shells were blown up by our Shells. To day I again proposed (for I had done it before) erecting a Battery behind the covered Way in the Saliant Place of Arms before the Demi Bastion, and at last had permission about 6 in the Evening and a Working Party of 100 fresh men, which I immediately set to work under Lieut. Eiser and Stevenson. This Battery of at least 5 Guns I thought absolutely necessary to render our fire equal to the Enemys; for their Battery of 7 or 8 Guns fronts directly the face of the old North East Bastion and will fire on the North face of the Demi obliquely. To oppose this fire we have only three Guns on the North East Bastion which bear direct, 2 in the North Ravelin fire in an oblique Line and 3 or 4 from the Royal Bastion which also fire oblique and therefore have no great Chance of ruining the Enemys Guns. Now the new Battery I propose will be a direct grazing fire, and can neither be infiladed, nor beaten down because the Glacis is the Parapet, and the Embrasures will be cut thro' it. In the morning a small Sloop or Boat which the Enemy had stopp'd fell down to St. Thomé and about 5 in the Evening sail'd to the Southward with 17 Boats which arrived from the Southward just before. The working Party was 100 men beside 200 Sepoys employ'd as before.

6th. Our fire from the Cannon and Mortars was not last night very brisk. The Enemy in the morning as soon as they cou'd well see threw five Shells into the Town as a signal for their other

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Batterys to begin, And about seven began to fire from 6 Guns and as many Mortars from their North Battery (B), and from their West Battery (D) with three Guns pointed on Pigots Bastion (g) and 4 (E) with an Howitz firing on the flank of the Demy Bastion and infilading the covered Way before the North face of the Royal Bastion. From these Batterys they continu'd to fire till about five in the Evening, and threw near 150 Shells besides Shot chiefly into and over the Town. The Damage done the Works is very trifling, but the houses in the Town where Shells or Shot fell have suffered much. Our fire of Artillery and Mortars was much superior to the Enemys, and to appearance greatly disordered their Merlons. We also learn by a Deserter from the Enemys Artillery that our Shells dismounted one of their Mortars, and killed three Men in the North Battery. The working Party was 100 Men, and chiefly employed in forwarding the Battery in the North East Angle. As to Sipoys or blacks we had little or no work from them.

7th. Last night the Enemy threw but few Shells and we only a Shot or Shell now and then. About 4 in the Morning we were surpriz'd with the Arrival of three Boats with a french man in each. They were the boats which had been sent the 3rd Instant with the Ladys to Sadrass. The French having Seiz'd that place also seiz'd the Boats, and loading them with 150 Shot of 24 prs. 1000 Empty Cartridges, 50 steel Caps, 50 Barrels of Powder and 1500 Sand Bags, sent them back with a Soldier in each to the black Town. The Boat fellows towards the morning being opposite Madrass seiz'd the Arms of the Sleeping Soldiers, pour'd water on the Locks, then tied the Men and landed the Boats at our Sea Gate. This Action of the boat fellows is well worth recording, and will be perpetuated if Madrass is sav'd as long as they live by some Reward to them and their familys; the value of the things has also been paid them. The Enemys Fire was very brisk till five in the Evening from their Cannon and Mortars; and then they ceas'd from both In order I suppose to repair their works. Our Works tho' not much damaged bear however a rough aspect, and the Demi Bastion as well as Pigots is stuck pretty full of Shot. The Shells the Enemy threw, have greatly damaged the houses in Town but have not hurt many people, three Europeans only being killed this Day. Our working party cou'd do nothing in the Day; a few indeed attempted to work in the N. East Saliant Angle of the covered Way but the Enemy having discovered them fired so briskly that Mr. Stevenson who directed them was knock'd down by the Wind of a Shot, but only slightly hurt on the Cheek, so the party return'd. In the Afternoon we were disagreeably alarm'd by a report from the Steeple of 12 Sail being in Sight to the Northward, which soon vanish'd to Catamarans, and then to nothing. The Enemy opened a new Battery of two Guns near the burying Ground (F).

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8th. As I found the Soldiers unus'd to such Duty were in general extremely aukward in repairing the damaged Works I conceived that the Service wou'd be much better carried on by appointing a Pionier Company, composed of Volunteers drawn from the several Corps, and to do no other Duty but repair the Works. So that by constantly employing the same people they might more readily execute the service they were set about. I accordingly made application to the Governour, and the thing was granted. The Company to consist of 2 Officers Lieut. Meyers, and Ensign West, 6 Serjeants, 6 Corporals, and 88 privates. Two Companys of Sepoys were also form'd with proper officers on the same Plan. The Working Party was this Evening 100 Soldiers and as many Sepoys employed in repairing the Embrasures, Platforms, and forwarding the Battery in the covered Way before the Demy-Bastion.

9th. This Morning the Enemy opened 2 Embrasures more from their Battery near the burying Ground and some Earth appeared to be cast up near a little upper room house beyond the Pettah Bridge (h). In the night they threw a good many Shot and Shells after Eleven o'Clock. During the Day their fire was very brisk from their Cannon, but many Shells were not thrown by them. Ten Grenadiers were posted in the N. East Angle of the covered Way to fire into the Enemys Embrasures, and 2 Twelve pounders were fired from the new Battery. The working Party of 100 Men and 100 Sepoys with 6 Artificers were employed in repairing the Embrasures, Platforms and other Damages done the several Works. Also in cutting up a damaged Stone Platform on the old North East bastion, and laying one of wood. A blind of 12 feet thick and seven feet and half high was begun 35 feet behind the flank of the Demy Bastion to cover the people on that Work from the Enemys shot which might come in at the Embrasures of the flank or en ricochet over it. The Merlon next the Shoulder was rose for the same purpose. In the Evening two Sail appeared to the Southward, and anchored near St. Thomé, with white Colors being both of them Ships.

10th. Last night the Enemy threw very few Shells and fired not many Shot. On our side we were almost as silent. The two Ships which appear'd to the Southward still remain at an anchor near St. Thome, and as far as we can discover are french Ships from Pondichery. Our Working party was last night 100 Pioniers, and 60 Grenadiers, besides 160 Sepoys. They were employed in compleating the covered Way Battery to four Pieces of Cannon which were mounted before Morning: In filling Bags of Earth at the foot of the Demi bastion, and clearing what the Enemy had beat down. In repairing the Parapets of the Demy, N. East, Royal, and Pigots Bastions and laying two wooden Platforms on the first Bastion in the room of two Stones ones damaged. In the night the Enemy carryed on part of a Zig Zag about 100 feet long nearly westward

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from their northern Battery (k.l.), and taking a turn carryed another 200 feet long back towards the Sea Side as marked in the Plan (m.n.). They also drew part of a trench (L) from the little house in the Pettah towards the Bridge, and repaired their Shattered Merlons with Sand bags.

11th. Last Night the Enemy were almost wholly silent with their Artillery and Mortars, but were not idle with their Shovels for in the morning we discovered that they had deepen'd their Zig Zags begun the preceeding night to the Northward and Lengthened that which stretched towards the Sea almost to the Beach (o). They had also drawn their Trench from the little house quite to the Pettah Bridge, and opened a Battery of two Guns from the Cook room of the new hospital (G) which fired on the N. West Curtain, and the blind before the Mint Sally port, but I suppose were intended to plunge into the Royal Bastion, and batter the East flank in Reverse. Our Working Party was 90 Men of the Pionier Company and 60 Voluntiers Grenadiers besides 160 Sepoys employed in repairing the damaged Merlons and Platforms of the North front, dismounting some disabled Guns, and making blinds before the Doors and windows of the Arched hospital under the old West Curtain. Also in filling Sand Bags at the foot of the Demi-Bastion, and clearing the Earth beat down. This Afternoon I examined the Works as to their State, and observed that the Parapets of the North face of the Demi Bastion are a good deal shattered, that the brick Parapet of the North face of the old N. East Bastion is wholly ruin'd, but the wall being well covered by the blind of Gabions made before it is not much hurt. The West face of the Royal Bastion is but little hurt below the Cordon. And the right hand face of Pigots Bastion being built to a great slope the Enemys fire has had no other Effect than beating the Earth to its natural Slope which is from the extremity of the berm to the top of the Parapet. The old Curtain Wall to the Northward is a good deal shattered about the Parapets, and most of the Pallisadoes of the Caponniere broke by the plunging Shot from the Enemy West Battery.

12th. The Enemy having yesterday brought a field piece or two near the Barr (12) and fired a few Shot on the people and Bullocks which had taken Shelter to the Southward of the Fort; and there appearing to be a breast work and Guard of the Enemy near the sea side it was determined to attack that Post early this morning; accordingly as soon as the moon was gone down the 2d Battalion Grenadiers under Captain Campbell and near 100 Men more with 300 Sepoys all under Major Brereton marched by the Sea Side to the barr, and there received the fire of the Enemys advanced post by which we lost 1 killed and two Wounded of the Grenadiers. Our people without firing marched on to the Governors Garden house, (13) and in a small Lane or street on the South side of it found the

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Enemy drawn up with 2 small field pieces and about 50 men. The Enemy fired two discharges of Grape on our party within 50 paces, but the Gunners being killed they made no other use of their Guns. On the contrary the Picquet broke and ran each his own way. The Guns were taken and brought in, 1 Officer and 6 Men were also taken Prisoners; and about 10 or 15 killed or left wounded on the Spot. On our side we had one killed, 1 Officer (Lt. Robson of the Grenadiers) mortally wounded, and 9 Men. This little affair has doubtless given our people great spirits, and damp'd those of the Enemy. A Party with an officer was also sent out in the night at St. Georges Gate which advanced on the bridge leading to the Pettah, and fired into the Enemys Trench but cou'd not perceive any people at work. About 7 in the Evening a party of the Enemy advanced towards our N. East Saliant Angle of the covered way and gave a fire thereon. In the night also a party of our men with an officer was sent out to disturb the workmen of the Enemys Zig Zags to the Northward who advanced to their work, fired on and killed their Centinel and took a stand or two of Arms without any loss. The Fire of the Enemys Cannon was pretty brisk yesterday but they threw very few Shells, and those not large. I cou'd not perceive that they had done much to their approaches last night, but the Merlons of their Batterys seem'd to be tolerably well repaired with sand bags. The working Party was the Pionier Company and about 170 Sepoys who were employed in making a Traverse on the North face of the Demi-bastion; carrying off the Earth at the foot of it; fetching Pallisadoes to set up in the dry ditch before the North face; and repairing the Damaged Platforms and Parapets. On the Royal Bastion, Old N. East, and covered way Battery the Parapets Platform and Embrasures were repaired.

13th. Last night about 7 o'Clock the Enemy advanced pretty near the covered Way on the N. East, and gave a fire of Musquetry on our people there at work. They also fired in the night from their approaches on a small party of ours posted on the Saliant Angle under cover of a boat, and wounded three Men. From the covered Way and North Lunette we cou'd plainly perceive the Enemy at work near the sea side, which we endeavord to prevent by frequent discharges of Grape, Musquetry, and Shells. Our Working party was 78 men of the Pionier Company, and 180 Sepoys who were chiefly employed in removing the Earth at the foot of the Demi Bastion, and the Rubbish before the old N. East, which works I was determined to repair, and secure as much as possible since the Enemy seem'd to bend most of their fire against those Works, and direct their attack that Way. I therefore rais'd and thickened the blind before the North East Bastion whose Parapet was much Shattered, and begun a Pallisadoe at the foot of the Demi Bastion 6 feet within the Cuvette which I propose to carry quite round the flank and

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North face. I also propose another between the blind and North face of the old N. East Bastion. The Enemy in the night had covered the Head of their Zig Zag near the Sea by a small return or Crochet (o.p.) beginning near the beach and stretching Westward parellel to the North front. To the Westward the Enemy fired with four Guns from the new Hospital but did nothing to their Trench near the Pettah bridge. Their Sepoys to the Southward of the Barr were at work all Day in raising a breast work for their defence in Case we shou'd make another attempt on that side.

14th. Last night as we imagined the Enemy wou'd be at work again at the crochet before their Zig Zag we began a pretty smart fire of Musquetry from our covered Way, and frequently gave them discharges of Grape from the North Lunette, and covered way Battery. From the Royal and Demi Bastions we threw small and large Shells into their approaches and Batterys, so that they were prevented from doing much Work. By the morning however they had run on their return about 20 Yards, and compleated what they had roughly traced the night before. Our working Party besides 75 Men of the Pionier Company was assisted by 120 Men out of the two Battalions and 170 Sepoys. The Earth near the Shoulder of the Demi Bastion having form'd an ascent almost practicable about 100 Europeans and as many Sepoys were set to carry it off in baskets or sand Bags to repair the Parapets of the bastion above. The Pallisadoe begun at the foot of the Bastion was continued near 100 feet more. The Parapet of the North East Bastion being quite destroy'd, and that work being of the greatest Consequence to be kept in good repair about 160 Europeans, and the rest of the Sepoys under Mr. Stevenson were set to clear away the ruin'd Parapets, and erect others with Sand Bags, Gabions and Fascines, two Merlons of which were finished before the Morning. An old Sally port in the East Curtain near the South flank of the old North East Bastion was opened for the more ready communication with the N. East part of the covered Way, and a Door placed in it.

15th. Last night a brisk fire of Musquetry, Cannon and Mortars was kept up from our covered Way, and the Works of the North front on the Enemys Approaches, and prevented them from doing more than lengthening their Crochet a little, and opening it in the middle (9) from whence they placed 15 or 20 Gabions in an oblique direction towards the Sea Side. Our working party consisted of the Pionier Company, the 1st Company of Grenadiers, and 90 men of the two Battalions, besides 2 Company of Sepoys. They were employed in finishing the Parapet of the old N. East Bastion which was put in very good Condition and three Guns mounted thereon ; In clearing the Earth from the face of the Demi-bastion, repairing the Parapet, and fixing Pallisadoes at the foot of it. On the Royal Bastion a blind was begun to cover the three Guns in the East Flank next the

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Curtain from the fire of the Enemys Battery near the new Hospital which takes it in Reverse. The Embrasures of St. Georges and the N. West Lunette being much out of repair a party of 20 Men, and a Serjeant, was sent to repair them. The fire of the Enemys Cannon was this Day very brisk, and their North Battery was augmented to 10 pieces of Cannon with which they fired in Salvo's on the old N. East Bastion, and soon dismounted 2 of the three Guns.

16th. Last night a Picquet of the Enemys advanced to the Boat and drove an advanced party of ours from thence. The fire of Musquetry from the covered way, and the Cannon and Mortars from the bastions, and North Lunette, was well kept up on the Enemys approaches. They in return threw a few Shells and fired a few Shot into the Town and Works, by which one of the working party was wounded. From the Method of the Enemys carrying on their approaches, their Numbers, and our expectation, there is room to believe some sudden attempt will be made on Madrass, and that by the Sea side, and on the N. East Angle of the covered way. To prevent such a stroke as much as lay in our Power it was proposed to carry a breast work from the covered Way on a square with the Angle of the Demi Bastion quite across the Glacis down to the surf, but on examining the Ground, it appeared that such a breast work woud prove more prejudicial than useful by intercepting the fire of the Fascine Battery, and was therefore laid aside. Our working Party of 64 Pioniers, 60 Grenadiers of the 2d Battalion and 130 Sipoys were employed in repairing the Parapet of the old N. East Bastion, which was again compleated for three Guns. In repairing and covering by some Gabions the Pallisadoe before the Fascine Battery near the Sea. In clearing the Earth from the foot of the Demi-bastion, and therewith thickening the blind before the old North East. Repairing the Parapets and Embrasures above, and carrying the Pallisadoe below. This Day the Enemy threw a great many Shells into the Town particularly the North End, and killed or wounded us more men than in any preceeding one, among the rest 2 of the Pionier Company were killed at their Barrack Door, and most of the others were also off Duty. The Enemy last night had augmented their North Battery to 12 Embrasures, and fired from thence very briskly on the old N. East and Demi bastion. They also filled the Gabions they had left empty the night before, and advanced their Work in the same Direction about 20 Yards (r). About 10 in the morning a Snow appeared to the N. East and anchored, on which the French Frigate chas'd, and all their Ships threw out English Colors.

17th. Last night an incessant fire was kept up with Musquetry from the covered Way, and about 12 o'Clock an officer with 12 Men was sent out to fall on the Enemys workmen which he fired on several Times but a large body advancing he was killed himself,

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and 3 of his men wounded. Notwithstanding the Interruption we gave them, the Enemy carried on the remaining part of their Zig Zag to (s), and covered it by a Crochet or Boyau (t). Our working party was 76 of the Pionier Company, the first Company of Grenadiers, and 24 Serjeants and Corporals off duty, besides 130 Sepoys. They were employed in repairing the Parapet of the old N. East Bastion which was put in order, and a Platform Lengthened for three Guns, the same Number as at first. The Blind below was thickened, and the Rampart of it enlarged. The covered Way Battery being deem'd no longer useful the Guns were drawn off in the afternoon, and the Platforms taken up. In the night we closed the Embrasures and lowered the Merlons into a regular Slope. Many of the Pallisadoes which were fixed in the dry ditch having been destroyed by the Enemys shot and Shells were replaced, and others fixed round the flank of the Demi bastion. The Embrasures of the Demi-bastion next the Saliant Angle were filled up, the Merlons of the 3 Embrasures next the Shoulder were repaired, and the Parapet strengthened. The Earth at the foot of the face was entirely carryed away.

18th. Last night the Enemy brought two Guns down to the Barr and fired a few shot at some Sepoys of ours posted on the opposite Side. Yesterday and this night the Enemy threw a great many Shells into the Town and some into the Works which did us more damage than any they threw before. The Enemy yesterday in the Afternoon worked at thickening the sand bank to the right of their battery close to the Sea, and this morning they opened three Embrasures thro' it, which in the afternoon fired on the N. East face of the North Lunette, so that their North Battery now consists of 15 Embrasures the Enemy extended their Parallel or Crochet (t) at the foot of the Glacis westward about 15 Yards but in a rough unfinished manner as indeed their whole work appears to be. Our working Party last night consisted of 76 Pioniers, the 2d Company of Grenadiers, and 130 Sepoys who were employed in clearing the Earth at the foot the Demi-Bastion, finishing the Pallisadoes in the dry Ditch, Levelling the Earth in the N. East Angle of the covered Way, raising, and thickening the blind before the old N. East Bastion, and giving the Parapets of that bastion an entire repair. To Day the Enemy fired not from their battery near the old hospital, and the Embrasures appeared clos'd up.

19th. Notwithstanding the fire which we kept up last night from our Musquetry, Cannon, and Mortars, the Enemy advanced by a third Zig Zag (v) across the Saliant Angle of the Glacis. In the forenoon the Enemy fired pretty Smartly from their Musquetry behind their first Crochet. They also brought two heavy Guns (O) to the South of the Barr, and threw some Shott into the Town. Our working party last night was 1 Officer, 3 Serjeants, and 56

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Pioniers, the first Company of Grenadiers, and 32 Serjeants, and Corporals who were employed in Levelling the Earth rais'd for the Guns in the N. East Angle of the covered Way ; clearing the Earth from the foot of the Demi Bastion ; carrying a Pallisadoe across the dry Ditch before the East Wing ; thickening and raising the blind ; and repairing the Embrasures of the North East Bastion. The Enemy Shells this Day set fire to the Sorting Godown, to a Godown in Gloucester Lane, and to some *Salt Petre in Middle Gate Street, so that the Town was on fire in three places at once, and the fire suffered to burn out.

20th. Last night the Enemy threw very few Shells, or Shott into the Works, or Town ; nor did they advance their Works more than by producing the 3d Zig Zag from the ridge of the Glacis obliquely to the Sea Side where they crown'd it by a small return of 4 or 5 Gabions. In the afternoon I observed a few Europeans working at a barbet Parapet (O) near the fishers Huts to the Southward of the Bar where the Enemy had brought two large Cannon, or 1 Cannon and 1 Mortar, for such they appeared to me. Our working Party was the Pionier Company and 120 Sepoys employed in the same Manner as yesterday except driving rows of Pickets in Front of the Fascine Battery, and making a breast work before the Pallisadoe which seperate the Demi-Bastion from the 2d Curtain.

21st. Last night the Enemy threw few, or no Shells, and fired less than in any night of the Siege, nor did they make any apparent approach in their Works. They thicken'd their 2d Zig Zag, and crochet, and laid some sand Bags for their Musquetry. Our Working Party consisted of the Pionier Company, and 120 Sepoys who were employed in repairing the Parapets, and Embrasures of the old N. East Bastion, in finishing the blind for Musquetry ; in clearing the face of the Demi Bastion ; and driving Pickets in the front of, and laying Fascines on the Fascine Battery ; repairing the Parapet and Embrasures of the left face of the North Ravelin ; and in clearing the Sea Gate of Rubbish, and making a traverse before the Gate of the Redout. The Enemys Batterys were this Day very silent, but they fired pretty briskly from their Trenches on such of our people as appeared at the Embrasures, or over the Parapets. The Enemys Method of proceeding by simple Sap in so confined, and unsupported a manner as their approaches are form'd giving great room to believe a Sally might easily drive them from their Works, and over sett some of the Gabions, it was determin'd to send out thirty soldiers, and 40 Pioniers to try what cou'd be done. A little past 5 in the

* Many Godowns were burnt during the Siege, and parcells of Salt Petre which we suppos'd not inflammable took fire, and raged with the greatest fury, being fed by the Bags and other inflammable substances.

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Evening 10 Men and a Serjeant went out by the sea side, and an officer with 20 Men went out by the Barrier in the N. East Angle of the covered Way. An Engineer with the Captain of Pioniers, and 40 Men followed. The Soldiers were to possess the Enemys 2d Crochet, and cover the Pioniers while they destroyed the Lodgement forming on the Ridge of the Glacis. Every thing succeeded as we cou'd wish ; the Enemy ran out of their Sap in an Instant, and our Pioniers for about 8 Minutes worked hard at distroying Gabions, and such things as they found. The Enemy then began to collect in their first Crochet and a Signal was made for the return of our Party. We lost 2 Serjeants killed, and 3 or 4 Pioniers wounded, what the Enemy (who had mostly Sepoys in their Works) lost we cant guess, but as our Cannon, Mortars, and small Arms play'd briskly on them before, and after the Sally, they no doubt must have suffered. It was apprehended they were carrying a Gallery under the Glacis in order to open the covered way by a Mine but nothing of that kind was discovered.

22nd. Last night the Enemy did not advance their approaches but worked at thickening their 2d Crochet, third Zig Zag and raising the head of their Sap (w) on the ridge of the Glacis. They fired few Shells, and those chiefly into the Works. During the Day the Enemy fired very few Cannon particularly from their Northern Battery where most of the Embrasures seem to blinded. Our Pionier Company having been out on the Sally we cou'd only get a Serjeant and 12 Men to work in the night who were employed in repairing the Parapets of the old N. East Bastion, and 100 Sepoys who work'd at a Traverse before the Pallisadoe .which serves as a Barrier between the Royal Bastion, and low Curtain. They also carried Pallisadoes down to the Fascine Battery, and did several other trifling Jobbs.

23rd. Last night a brisk fire of Musquetry was kept up on the Enemys approaches, however they advanced a few Gabions on the Glacis (x) almost Parrallel to the East face of the covered Way, and they opened a Battery (H) of four Embrasures in their 3d Zig Zag with an intent to fire on the right face of the North Ravelin, but it did not answer their expectations in bearing well on that Work. Our working Party of 63 Pioniers and 100 Sepoys were employed in repairing the North East Bastion, in making a Traverse before the Gate leading into the Caponniere from the low Curtain, another before each of the Gates which close the Communication to the Royal and Demi Bastions. Also in filling Sand Bags in the North East Angle of the covered Way, and carrying them to the several Works. Two Embrasures were repaired, and 1 Platform on the Demi-Bastion. And one Platform on the North Ravelin.

24th. Last night the Enemy attempted to push their Gabions close to our covered Way, but some of our men posted there over-

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sett many which roll'd into the Sea, and pull'd others in between the Pallisadoe. A smart fire of Musquetry commenced on this occasion and continued two or three hours in which we lost 10 or 12 Men killed, or wounded. From the North East bastion, and Fascine Battery, the field pieces fired Grape in such plenty that 70 discharges were made out of one Gun. The Enemys Loss from such a fire must doubtless have been great, and their work appeared this Morning rough and in-compleat. Our working party was 60 Pioniers, and 100 Sepoys, who were employed in repairing the old North East Bastion, in repairing the Embrasures of the North Ravelin, and making a blind behind the flank of the Royal Bastion; but the Pioniers being sent for to go, and over sett the Enemys Gabions little work was done. We lost of that party 1 killed and 2 wounded.

25th. Last night the Enemy push'd on their approaches in a Line Parallel to the East face of the covered Way as far as the Palmeira Pallisadoe (y), which runs quite into the Sea, parallel to which they made a Return. In the night a small party of our Pioniers went, and pulled several of the Enemys Gabions into the covered Way, and a small party of Grenadiers alarm'd them in their Trenches. Our Working Party consisted of 53 Pioniers, and 100 Sepoys, who were employed in repairing the Embrasures of the old N. East Bastion, in repairing the Parapets and Embrasures of the North Ravelin; filling in the Shell holes in the Caponniere, and making a Banquet behind the Traverse Leading to it. About 2 oClock in the Afternoon it was determined to make a Sally with 20 Men of the Guard behind the blind and 20 of the Pionier Company with an intent to destroy the work the Enemy had done the Preceeding night. They accordingly went out, and drove the Enemy from their approach behind the Stockadoe, and our Pioniers endevored to demolish their Work by oversetting the Gabions and throwing the tools they found into the Sea, or our covered Way. After maintaining their Ground near 15 Minutes the Enemy begun to grow very numerous in their Crochet on the ridge of the Glacis, on which our people were ordered to retire. We had Captain Black who commanded the 20 Men wounded thro' the leg, and Lieutenant Fitzpatrick of the Grenadiers (of whom 20 went out during the Sally) thro' both his Arms, 2 or 3 Men and 1 Serjeant killed. The Enemy must have suffered considerably from our fire which was kept up very briskly from the Works above an hour.

26th. Last night the Enemy push'd on their approaches in a Line almost Parallel to the North face of the covered Way before the Demi-bastion, and made a return (z) at the End of it to cover their flank so that by the Work of this and the preceeding Night they wholly embraced the Saliant Angle of our covered Way, and consequently made it too hazardous for us to keep Troops therein. Our working Party last night consisted of 53 Pioniers, and 88 Sepoys,

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who were employed in repairing the North East Bastion ; the Parapet and Embrasures ; in repairing the Embrasures and Parapets of the Fascine Battery ; and lengthening it towards the Sea ; and at the Sea Gate Redout in shutting up the great Gate which was damaged and very difficult to pass by the falling of the Virando ; and opening the small Gate on the South side. Also in clearing the rubbish from the North Flank of the Battery, and filling the Gabions placed on the face. To Day the Enemy fired most of their Shott from their several Batterys into the Town, but threw their Shells chiefly towards the Works on the North Front.

27th. The Enemy last night did nothing but widen, and raise the Work of the preceeding night, which we in some degree impute to the Detachments they made to oppose Usoff Cawn and Capt. Preston who we heard were at Ponamallé. Our Working Party consisted of 47 Pioniers, and 90 Sepoys, who were employed in repairing the North East Bastion ; in repairing the Embrasures of the Flank of the Royal Bastion ; and in repairing the Parapet, and Embrasures of the North East Lunette. They also worked during the Day at the Sea Gate Redout when the North Flank was entirely repaired, and embrasures form'd for four Guns. In the Afternoon Usoff Cawn's Signal of great smoke was seen west of Egmore, and an Hircar came in with a Report that the French had been beaten by our Troops.

28th. The Enemy did not Last night to appearance work much at their approaches, owing I suppose to the extraordinary Guards they were obliged to keep on Account of Usoff Cawn whose Horse were yesterday very near Egmore. This morning the French black Horse, Foot, and their European Cavalry were drawn up in a Line between Egmore and Captain Maskelynes Gardens, and by their motions to the right, and left, we expected that Usoff Cawn was near them especially as several smokes were seen that way, however nothing appeared. In the forenoon we observed that the Enemy with several Yoke of Oxen intended to draw off the Guns they had to the Southwd. of the Bar but on our firing a few Shot the bullock drivers, and Bullocks disappeared. The Enemy having now surrounded our N. East Salliant Angle, and probably intending to make a Battery on the Glacis, it was determined to try last night if we cou'd push a Mine from the Counterscarp that way. An Engineer and 8 Men were accordingly set to open an arch which had been turn'd in the Counterscarp for that purpose. The rest of the working Party being 32 Pioniers and 80 Sepoys were employed in repairing the Parapet and Embrasures of the right face of the North Lunette, and making a Ditch before the South Flank of the Sea Gate Battery in which a Pallisadoe was fixed.

29th. Last night the Enemy drew off one of their Guns to the Southward, but we cou'd not perceive that they had worked anything

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at their approaches 'till after 2 oClock in the afternoon when they were discovered throwing up Earth thro' a Small hole just within the Banquet in the covered Way opposite the Stockadoe (y) which was place on the Eastern Glacis. Thro' this I imagine they were working by covered Sap with an intent to open the Counterscarp under cover of the Saliant Angle of the Demi Bastion where they cou'd not be seen from the flank of the Royal, but having come too near the Surface the Earth fell in and they were discovered.* Some Grenadiers were immediately sent out to fire into the hole, and throw Grenades which they did, and thereby stopt the Enemys working. Our working Party was last night 37 Pioniers and 60 Sepoys who were employed in carrying on the Gallery, and in raising the right side of the Caponniere to cover our people passing, and repassing to the North Ravelin. Twelve Men and a Serjeant with some Boatmen worked in the Day at the Sea Gate in raising the South Flank of the Battery, and filling up the useless Embrasures.

30th. The Enemy were last night quite Silent in their Trenches but threw plenty of Shells into the Town, and at the North Ravelin. By their silence and other appearances we concluded they were making a Battery some where on the face of the covered Way, or carrying on a Gallery towards the blind. Our working Party consisted of 45 Pioniers, and about 75 Sipoys who were employed in pushing on the Mine, compleating the right side of the Caponniere, and in repairing the Parapet, and Embrasures of the right face of the North Ravelin. A Sail which had been in sight to the Southward all Day came into the road towards the Evening under English Colors, and proved to be the Shaftsbury from Bombay, having been left by the other 4 India men and 2 Twenty Gun ships which came as a Convoy the 7th Instant off Zeilon, and expected to have found them here. This Ship being the worst Sailor had been made an Hospital Ship and therefore brought us no men but what were sick, and added to our distress for room.

31st. The French Frigate last night came near and recd. a broadside from the Shaftsbury and then sail'd to the Southward, and to Day in the Afternoon returned into the road again. A little before her return several Boats were seen going with Men to the Haarlem a Dutch Indiaman siezed by the French; which Ship immediately weigh'd and stood towards the Shaftsbury, who slipp'd her Cable and stood quite under our Guns. The Haarlem fired several Shot at our Ship, and followed her so close that we tryed to reach her with the Guns from the Sea Line but she was at too great a range to fire with any certainty. The Enemy from their Battery of Two Guns to the Southward (O) and one from the

* We have learnt since that an Engr. and four miners were stifled by the falling of the earth.

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Northward (H) Struck the Shaftsbury several Times, but night coming on saved her from the Damage she must otherwise have received. Early in the Morning the Enemy opened four Embrasures on the North face of the covered Way before the Demi Bastion, and begun to fire with three Guns, but the Earth in the Cells of their Embrasures was so high and the Battery so ill constructed that after firing Twenty or thirty Shot, none of which came within several Feet of the Top of our Parapets, the Battery was silent, not only from its inutility but I imagine some of the Guns were dismounted by the fire from our N. East Bastion. The Working Party last night was 48 Pioniers, 12 of which were employed in pushing on the Mine, the rest in clearing the Earth from the Demi-bastion and repairing the Fascine Battery. It being also imagined that the Enemy were pushing on a Gallery behind the Counterscarp under the narrow covered Way to the Eastward with an intent to destroy our blind or blow up the covered Way, it was determined to open another Gallery from the covered passage under the blind, and carry it on to meet the Enemy in case they shoud advance that Way.

(*To be continued*).

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SIEGES AND THE DEFENCE OF FORTIFIED PLACES BY THE BRITISH AND INDIAN ARMIES IN THE XIXth CENTURY.

(Continued).

By COLONEL SIR EDWARD T. THACKERAY, V.C., K.C.B. (LATE R.E.).

FIRST AND SECOND SIEGES OF BADAJOZ.

The retreat of the army under Marshal Massena having virtually freed Portugal from the French, Wellington began to contemplate extensive and decisive operations in Spain. Before being able to carry these out, however, it was necessary for him to recapture Almeida and Badajoz, which had been taken by Marshal Soult whilst the Allies were still occupied with the defence of Lisbon. As soon therefore as Massena had crossed the frontier Wellington invested Almeida and after the defeat of the French at Fuentes d'Onor its retention by them was rendered practically hopeless. Unfortunately the carelessness of some of the subordinate generals allowed General Brennier, the Governor, to escape in safety with the garrison after he had successfully ruined the fortifications, but its fall allowed Wellington to turn his whole attention to Badajoz. He soon realized that, although its capture would tend greatly to the security of the Portuguese provinces on the left of the Tagus, it would not enable him by any direct operations to weaken the strong hold the French had obtained on the south of Spain. He rather proposed, if Badajoz should fall, to attack Ciudad Rodrigo, and thus render secure the Beira and the northern districts of Portugal.

Sir John Jones in his *Sieges in Spain* describes the fortress of Badajoz as follows :—" Badajoz is a large fortified town situated on the left bank of the Guadiana ; which river is there from 300 to 500 yards broad and washes about one-fourth of the enceinte of the place, rendering it nearly inattackable ; the defences to the land consist of eight large well-built regular fronts, with a good covered way and glacis, but the ravelins unfinished. The fronts have whole revetments, and the escarp of the bastions exceeds 30 ft. in height, that of the curtains being much lower : in advance of these fronts are two detached works ; one called the Pardaleras, at 200 yards distant, is a crown work ; its escarps are low, its ditches narrow, and its rear badly closed ; the other, called the Picurina, is a strong redoubt at 400 yards in advance of the town. On the N.E. at the angle formed by the junction of the river Rivillas with the Guadiana,

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rises a hill to the height of 120 ft., the summit of which is crowned by an old castle, and its walls naked, weak, and but partially flanked, here form part of the enceinte of the place.

The space contained within the castle is considerable, and various projects have at different times been under consideration for occupying it by works, but nothing had ever been carried into effect; indeed the defences of the castle had been unaccountably neglected; two or three fieldpieces only being mounted on its walls, and those without the shelter of proper parapets.

Immediately opposite the castle, on the other side of the Guadiana, at a distance of 500 yards, are situated the heights of Christoval, rising to nearly the elevation of the castle; and as the terreplein of the castle is an inclined plane towards the Guadiana, every part of it is seen from the Christoval Heights; to prevent an enemy readily availing himself of this advantage in any attack of the town, a fort has been constructed on them; its figure is nearly that of a square of 300 ft.; the scarp is well built of stone, and is 20 ft. in height. The communication between the town and Fort Christoval is very open to interruption, being either by a bridge 600 yards in length, subject to be enfiladed, or by boats for which there is no security."

From the above it will be seen that the task before Wellington was an exceedingly formidable one, but he determined to lay immediate siege to the fortress if any plan of attack could be evolved which would not require more than 16 days' open trenches. This was all the time that could be considered available, as in that period, including the time required to complete the necessary siege preparations, Marshal Soult would be able to collect a sufficient force to raise the siege. The proper point of attack was one of the south fronts, but to approach either of them would have entailed the reduction of the Pardaleras outwork which would have necessitated the opening of the trenches at a greater distance than usual from the fortress. To carry out this plan of attack would have needed a period of at least 22 days and, in addition, it was realized that the means provided were wholly insufficient to ensure success.

Under these circumstances the Chief Engineer, Colonel Fletcher, proposed to breach the castle, while batteries established on the right bank of the Guadiana took the defences in reverse. False attacks against the Pardaleras and Picurina were to be made by reopening Soult's trenches, and it was necessary to reduce San Christoval before the batteries to take the castle in reverse could be constructed. With this object in view Capt. Squire was directed to break ground there on the night of the 8th of May. The moon shone brightly, he was ill-provided with tools and exposed to a destructive musketry fire from the fort and to shot and shell from the town; nevertheless he worked with great loss until the 10th of May when the French

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made a furious sortie and carried the battery. They were immediately driven back by the reserves, but the Allies pursued too far, and being taken in flank and front with grape lost 400 men. By this time five engineers had fallen and 700 officers and soldiers of the Line had been sacrificed, and only one small battery against an outwork was completed! On the 11th it opened, and before sunset the fire of the enemy had disabled four of its five guns, and killed many more of the besiegers; nor could any other result be expected, since the concert essential to success in double operations, whether in sieges or the field, was neglected. Squire's single work was exposed to the undivided fire of the fortress, up to the time of the approaches against the castle being commenced; and two distant batteries which had been constructed at the false attacks scarcely attracted the notice of the enemy. To check further sallies, a second battery was erected against the bridgehead, but this was also overmatched, and intelligence having been received that the French Army was in movement, the progress of all the works was arrested by Beresford. On the 12th, believing that this information was premature, he directed the trenches to be opened against the castle. But the intelligence proved to be true, and being confirmed at 12 o'clock the same night, the working parties were again drawn off and measures taken to raise the siege.

On the night of the 13th all the batteries were dismantled and on the night of the 14th such materials as could not be moved were burned. Part of the Army had already marched to Valverde to oppose Marshal Soult who had already reached Llerena, and on the 15th the remainder of the besieging force moved to join it. Sir John Jones remarks that this raising of the siege was in truth most fortunate, as at that period the strength of Badajoz was not duly appreciated, nor was it realized that the means prepared for the attack were altogether too inconsiderable. "The besieging corps itself," he adds, "was too small, particularly to attack Christoval; from which, and the want of entrenching tools, a sufficient extent of ground to oppose a proper front to the enemy could not be opened the first night and gave an opportunity for the sortie." He also points out the inexperience of the Portuguese gunners and the numerical and other inferiority of the besiegers' guns, and he concludes by saying that, had the enemy not caused the siege to be raised "after a great sacrifice of men, in other feeble attempts, it would have brought itself to a conclusion from inability to proceed."

As mentioned above, the last troops drew off from Badajoz on the 15th and on the 16th Marshal Beresford defeated Soult at Albuera. As soon as the retreat of the enemy was known on the morning of the 18th, the cavalry was sent in pursuit of them, and on the same day Major-General Hamilton's Portuguese Division resumed the blockade of Badajoz, on the south of the Guadiana.

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There is no operation in war more certain than a modern siege if the rules of art are strictly followed; and unlike the ancient sieges in that particular it is also different in this, that no operation is less open to irregular daring, because the course of the engineer can neither be hurried nor delayed without danger.

Wellington knew the Siege of Badajoz in form required longer time and better means than were at his disposal; but he was compelled either to incur danger and loss of reputation, which is loss of strength, or to adopt some compendious mode of taking the place. The time he could command, and time is in all sieges the greatest point, was precisely that which the French required to bring up a force sufficient to disturb the operation. Their doing so depended upon Marmont, whose march from Salamanca to Badajoz through Baños or the Gata could not be stopped by Spencer, seeing that those defiles were commanded by the French positions; it was possible also at that season to ford the Tagus near Alcantara, and more than 20 days' free action against Badajoz could not be calculated upon. The battering-gun carriages used in Beresford's siege were damaged; the artillery officers asked 11 days to repair them, and the scanty means of transport for stores were diminished by carrying the wounded from Albuera. Fifteen days of open trenches, and nine days of fire was all that could be expected, and with good guns, plentiful stores, and a corps of regular Sappers and Miners this time would have sufficed; but none of these things were available.

Of the guns some were of soft brass and false in their bore; the shot were of different sizes and the largest too small; the Portuguese gunners were inexperienced, there were but few British artillerymen, fewer engineers, no sappers or miners, and no time to teach the troops how to make fascines and gabions. Regular approaches by the Pardaleras and the Picurina could not be attempted; Beresford's line of attack on the castle and Fort Christoval were therefore adopted, avoiding the errors of that general; that is to say the double attacks were to be pushed simultaneously and with more powerful means. San Christoval might then be taken, and batteries from it sweep the interior of the castle, which was meanwhile to be breached; something also was hoped from the inhabitants, and something from the effect of Soult's retreat from Albuera. In this hope the work was begun. Major Dickson, an artillery officer, conspicuous for talent, prepared with unexpected rapidity a battering train of thirty 24-pounders, four 16-pounders, and twelve 8-in. and 10-in. howitzers used as mortars by placing them on trucks. Six iron Portuguese ship guns were forwarded from Salvatierra making altogether fifty-two pieces; a convoy of engineer stores arrived from Alcacer do Sal; and some British artillery came from Lisbon to be mixed with the Portuguese, making a total of 600 gunners. The regular engineer officers present were 21 in number; 11 volunteers from the Line

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were joined as assistant engineers; and a draft of 300 picked infantry, including 25 artificers of the staff corps, strengthened the force immediately under their command.

Hamilton's Portuguese Division was already before the town, and on the 24th May at the close of evening, Houston's division, increased to 5,000 men by the 17th Portuguese Regiment and the Tavira and Lagos Militia, invested San Christoval. The flying bridge was then laid down on the Guadiana, and on the 27th Picton's Division arrived from Campo Mayor, crossed the river by the ford above the town, and joined Hamilton, their united force being about 10,000 men. The covering army which included the Spaniards was under Hill, and spread from Mezida to Albuera; the cavalry pushed forward in observation of Soult, and when intelligence arrived that Drouet was effecting a junction with that marshal, two regiments of cavalry, and two brigades of infantry quartered at Coria as posts of communication with Spencer, were called up to reinforce the covering army.

Phillipon had used the respite given him to level Beresford's trenches, repair his own damages, and obtain small supplies of wine and vegetables from the people of Estremadura, who were still awed by Soult's vicinity. Within the place all was quiet, for the citizens did not now exceed 5,000 souls, and when the place was invested parties of the townsmen, mixed with soldiers, were observed working to improve the defences. Wherefore, as retrenchments behind the intended points of attack would prolong the siege, a large telescope was placed in the tower of La Lippe at Elvas, with which the interior of the castle was plainly seen and all preparations discovered.

In the night of the 29th ground was broken for a false attack against the Pardaleras; and the following night 1,600 workmen, with a covering party of 1,200, sunk a parallel against the castle on an extent of 1,100 yards, without being discovered by the enemy, who did not fire until after daylight. The same night 1,200 workmen, covered by 800 men, opened a parallel 450 yards from San Christoval and 700 yards from the bridgehead. On this line one breaching and two counter-batteries were raised against the fort and bridgehead to prevent a sally; a fourth battery was also commenced to search the defences of the castle, but the workmen were discovered and a heavy fire struck down many of them.

On the 31st the attack against the castle, the soil being very soft, was rapidly pushed forward without much interruption; but the Christoval attack, carried on in a rocky soil with earth brought from the rear, proceeded slowly and with considerable loss. This day the artillerymen from Lisbon came up on mules, and the engineers hastened the works. The direction of the parallel against the castle made the right gradually approach the point of attack,

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by which the heaviest fire of the place was avoided; yet so great was the desire to save time that before the suitable point of distance was attained, a battery of fourteen 24-pounders with six large howitzers was marked out.

On the Christoval side the batteries were not finished before the night of the 1st June, for the rocky soil required that the miners should first level the ground for platforms; and the garrison having mortars of 16 and 18-in. diameter mounted on the castle sent every shell amongst the workmen. These huge missiles would have ruined the batteries on that side altogether, if the latter had not been on the edge of a ridge from which most of the shells rolled off before bursting; yet so difficult is it to judge rightly in war that Phillipon stopped this fire thinking it thrown away! The work was also delayed by the bringing of earth from a distance, and woolpacks purchased at Elvas were used instead. However in the night of the 2nd all the batteries were completed and armed with 43 pieces of different sizes, 20 being pointed against the castle; the next day the fire opened but the windage caused by the smallness of the shot rendered it ineffectual at first and five pieces were soon rendered unserviceable. Towards evening the practice became steadier, the fire of the fort was nearly silenced, and the covering of masonry falling from the castle wall discovered a perpendicular bank of clay. Next night the parallel against the castle was prolonged, and a battery for seven guns traced out 650 yards from the breach. On the 4th the garrison's fire was increased by several additional guns, and six pieces of the besiegers were disabled.

Christoval was now much injured and some damage was done to the castle from one of the batteries on that side; but the guns were so soft and bad that the rate of firing was greatly reduced in all the batteries. In the night the new battery was armed, the damaged works repaired, and next day the enemy having trained a gun in Christoval to plunge into the trenches on the castle side, the parallel was deepened and traverses constructed to protect the troops. Fifteen pieces still played against the castle, yet the bank of clay although falling away in flakes remained always perpendicular; one damaged gun was repaired on the Christoval side but two more had become unserviceable.

In the night the parallel against the castle was again extended and a fresh battery traced out 520 yards from the breach; on the Christoval side also some new batteries were opened and some old ones abandoned. During this night the garrison began to entrench themselves behind the castle breach and two additional pieces from Christoval plunged into the trenches with great effect. On the other hand the besiegers' fire had broken the clay bank, which took a slope nearly practicable, and the stray shells set fire to the houses nearest the castle, but three more guns were disabled. On the 6th

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there were two breaches in Christoval, the principal one seeming practicable, and a company of grenadiers with twelve ladders were directed to assault it, while a second company turned the fort by the east. Three hundred men from the trenches were at the same time pushed forward by the west side to cut the communication between the fort and the bridgehead, while a detachment with a gun moved into the valley of the Gebora to prevent any passage of the Guadiana by boats.

First Assault of Christoval.

Major McIntosh, of the 85th Regiment, led the stormers, being preceded by a Forlorn Hope, under Lieut. Dyas, of the 51st; and guided by the engineer, Forster, reached the glacis and descended the ditch without being discovered. The French had cleared the rubbish away, the breach had still 7 ft. of perpendicular wall, and above it were pointed beams of wood, and carts chained together, large shells being also arranged along the ramparts to roll down. The Forlorn Hope finding the opening impracticable was retiring with little loss, when the main body which had been exposed to a flank fire from the town as well as a direct fire from the fort, came leaping into the ditch with ladders. Then an effort was made to escalade at different points but the ladders were too short, and the garrison, consisting of only 75 men besides the gunners, made so stout a resistance, and the confusion and mischief caused by the bursting of the shells was so great, that the assailants finally retired with the loss of more than 100 men.

This failure was attributed by some to the breach being impracticable from the first, by others to confusion after the main body had entered. It is however evident that from inexperience, accident or other causes, the combinations for the assault were not well calculated; the storming party was too weak, the ladders few and short, the breach was not scoured by the fire of the batteries. The attack was also ill-combined, for the leading troops were repulsed before the main body entered the ditch. The intrepidity of the assailants was admitted by all sides, yet it is a great point in such attacks that the supports should form one body with the leaders; the sense of power derived from numbers is a strong incentive to valour, and obstacles insurmountable to a few vanish before a multitude.

During the night the iron guns were placed in battery before the castle, but two more of the brass pieces became unserviceable, and the following day three others were disabled. The bank of clay, however, sloped more, and Capt. Patton, of the engineers, examined it closely; he was mortally wounded in returning yet lived to report it practicable. The French as usual cleared away the ruins, and with bales of wool and other materials formed interior defences.

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They likewise arranged huge shells and barrels of powder with matches fastened to them along the ramparts, placed chosen men, each supplied with four muskets, to defend the breaches, and in that order fearlessly awaited another attack, which was soon made. For intelligence now arrived that Drouet was close to Lierena, and Marmont on the move from Salamanca, so that another attack on Christoval was ordered. This time 400 British Portuguese, and French men of the Chasseurs Britaniques, carrying 16 long ladders, were employed; the supports were better closed up; the appointed hour was 9 instead of 12; and more detachments were distributed on the right and left to distract the enemy's attention, cut off his communication with the town, and improve success.

Second Assault of Christoval.

Major McGeechy commanded the stormers, the Forlorn Hope was again led by the gallant Dyas, accompanied by the engineer, Hunt. A little after 9 o'clock the first troops bounded forward, and were closely followed by the support under a shattering musketry which killed McGeechy, Hunt, and many men, but the others with loud shouts jumped into the ditch; then the French scoffingly calling to come on rolled the barrels of powder and shells down, and the musketry made fearful havoc. The two leading columns united at the main breach, the supports also came up, confusion arose about the ladders, of which only a few could be reared, and the enemy standing on the ramparts bayoneted the foremost, overturned the ladders, and again poured their destructive fire upon the crowd below. When 140 had fallen the order to retire was given. After this failure the breach in the castle remained to be stormed; but the stormers could not there gather in force, between the summit and the interior entrenchment, unless Christoval was taken and its guns used to clear the castle of obstacles; this would have taken several days, and Soult was now ready to advance and on the 1st a blockade was therefore substituted for the attack.

This siege, in which 400 officers and men fell, violated all rules. The working parties were too weak, the guns and stores too few, the point of attack ill-chosen; the defences were untouched by counter-fire, and the breaching batteries too distant for the bad guns; howitzers on trucks were poor substitutes for mortars, and the sap was not practised; lastly the assaults were made before the glacis had been crowned and a musketry fire established against the breach.

It was not strange that the siege failed. It was strange and culpable that the British Government after such long wars should have sent an engineer corps into the field so ill-organized and equipped that all the officers' bravery and zeal could not render it efficient. The very tools used especially those supplied from the Storekeeper-

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General's Department were unfit for work; the captured French cutting instruments were eagerly sought for in preference; and when the soldiers' lives and the honour of England were at stake English cutlery could not bear comparison with French!

Want of foresight has also been objected to the general, inasmuch as he might have previously obtained a good battering train from England. But in the Lines, the conduct of the English and Portuguese Governments led him to think rather of embarking than besieging a frontier fortress; moreover the extreme badness of the Portuguese guns was not known before trial, and the time between Soult's capture of Badajoz and the siege was not sufficient for bringing out an English battering train. It may also be taken as a maxim that in the requirements of war no head was ever strong enough to fore-calculate all.

The second Siege of Badajoz terminated on the 9th of June but the blockade was kept up until the 16th. The junction of the two French armies under Marshals Marmont and Soult then rendered a retreat necessary and the fortress again became open. There was however, no collision between the armies, but on the 22nd of June the French pushed forward a strong reconnaissance which proved unsuccessful. After this both forces remained quiet for above a month, and it was during this period of inactivity that the preparations for the attack on Ciudad Rodrigo were commenced and that the battering train and siege stores were ordered up the Douro from Lisbon.

But it was not until the 8th of August that Wellington reached the Coa, intending first a close blockade of the fortress and finally a siege, but he was too late, the place having been re-victualled for two months on the 6th by Bessière's convoy. The blockade was therefore necessarily relinquished and the troops were quartered near the sources of the Coa and Agueda, close to the line of communication between Marmont and Dorsenne, and in a country where there was still some cover. From thence, if the enemy advanced in superior numbers, there was a retreat to a strong country and to a position of battle near Sabugal, from which the communication with Hill was direct. Nor was the rest of Beira much exposed, as the Allies could send detachments to the valley of the Mondego by Guarda in time to secure the magazines at Celorico; but the battering train and line of supply from Lamego was unprotected. In these positions the preparation for the siege went on until Wellington learned, contrary to his former belief, that Dorsenne's disposable force was above 20,000 good troops, and Ciudad Rodrigo could not be attacked in face of both that force and of Marmont's Army. Then, changing his plans, he again resolved to blockade the place and to be ready to strike a sudden blow against the fortress, or against the enemy's troops. For it was the foundation of his hopes, that, as the French could not long keep in masses for want of provisions, so he could

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check those masses on the frontier of Portugal, and always force them to concentrate or suffer the loss of some important post.

Early in September, Marmont pushed a detachment from Plasencia through the passes, surprised a British cavalry piquet, and thus opened his communications with Dorsenne. Wellington had, however, already formed his blockade, and three of his brigades reinforced by a Portuguese regiment were posted on the Ponçul, beyond Castello Branco, to protect the magazines on that line. The battering train then reached Villa Ponte, the troops made gabions and fascines, and 200 men of the Line were instructed as sappers; the Almeida Bridge on the Coa was permanently repaired, and Almeida was again restored as a place of arms for guns and stores.

During the first arrangements for the blockade in September, 1811, the garrison had made excursions to beat up the quarters of the British cavalry and to obtain provisions from the villages.

Mr. Stuart's exertions had improved the revenue; the ranks of the infantry were filled up by the return of deserters and by fresh recruits, which, with the reinforcements from England, had raised the Allied Army to upwards of 80,000 men, 56,000 being English. The number under arms, however, did not exceed 24,000 Portuguese and 33,000 British (of which 5,000 were cavalry), with 90 pieces of artillery. This was due to the fact that 22,000 men were in hospital, owing to the increasing sickness acquired in the Alentejo, so that, after deducting Hill's Corps, Wellington could not bring above 44,000 men of all arms to the blockade of Ciudad. But Marmont alone could in a few days bring quite as many to its succour; and Dorsenne had from 20,000 to 25,000 men available, because the French reinforcements having relieved the old garrisons in the north the latter had joined the army in the field. An aggravating sense of all his difficulties was pressed on the English general when he compared his own situation with that of the enemy. Neither his necessities nor his money could procure due assistance from the Portuguese, while the French generals had only to issue their orders to the Spaniards, through the prefects of the provinces, and all kinds of aid possible to be obtained were surely provided on the day and at the place indicated. In the midst of these cares Wellington was suddenly called into military action. Ciudad Rodrigo again wanted food, and Marmont, who had received 11,000 men from France and had 50,000 under arms, concerted with Dorsenne a combined operation for its succour.

SIEGE OF CIUDAD RODRIGO.

After the Allies came to Beira in 1811, Dorsenne and Marmont being reinforced became separately equal to Wellington, and, together, too strong. Soult, master of Andalusia, had a movable reserve of 20,000 men, Suchet gained ground in Valencia, the Asturias were

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reoccupied by Bonnet, and the army of the centre was reorganized. To besiege Ciudad Rodrigo in form was hopeless, and the rumour of Napoleon's arrival made the English general look once more to the lines of Torres Vedras; but when the certainty of a Russian war removed this fear, the capture of Ciudad Rodrigo became possible. There was then a good battering train in Almeida; the line of communication with Oporto was completely organized and shortened by improving the navigation of the Douro; Rodrigo itself was weakly garrisoned, and the French ignorance as to the state of the Allies' preparations gave hope of a surprise. It was, however, only from surprise that success could be expected, and it was not the least of Wellington's merits that he concealed his preparations for so long a period. No other operation was open, and yet he could not remain inactive because around him the whole fabric of the war was falling to pieces from the folly of the governments he was serving. If he could not effect a blow against the French while Napoleon was engaged in the Russian War, the Peninsula would be lost.

To surprise a third-rate fortress with a weak garrison seems a small matter in such grave circumstances, but in reality it was the first step in a plan which saved the Peninsula when nothing else could have saved it. Wellington knew the Valley of the Tagus could not long support the Army of Portugal and the army of the centre; he knew by intercepted letters that Marmont and the King were at open war upon the subject, and he judged that if he could surprise Ciudad Rodrigo, the Army of Portugal would, for the sake of provisions and to protect Leon uncovered by the departure of the Imperial Guards, concentrate in that province. This first step would therefore break the bar Napoleon had raised to offensive operations. For to keep magazines in reserve for sudden expeditions, feeding meanwhile as they could upon the country, was the French manner, and hence want of provisions never obstructed their moving upon important occasions; yet Wellington thought the tempestuous season would render it difficult for Marmont when thus forced into Leon to move with great masses; wherefore he proposed if Rodrigo fell to march by Villa Velha to Estremadura and suddenly besiege Badajoz also, the preparations to be secretly made in Elvas under protection of Hill's Corps. This was the second step and one of promise, because of the jealousies of the marshals, the wet season, and his own combinations which would prevent the concentration of the French armies and prevent them from keeping together if they did unite. If Badajoz fell, he designed to leave a force to cover it against the army of the centre and fight Soult in Andalusia. For he judged that Marmont could not, in default of provisions, pass beyond the Guadiana, nor follow him before the harvest was ripe; neither did he fear him in Beira, because the torrents would be full, the country

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a desert, and the Militia aided by a small regular corps and covered by Almeida and Ciudad Rodrigo, would be sufficient to prevent any serious impression on Portugal during the invasion of Andalusia.

This plan, subtle and vigorous, was the more daring because his own troops were not in good plight. He had indeed received reinforcements, but the infantry had served at Walcheren and exposure to night air or even slight hardships threw them by hundreds into the hospital, while the new regiments of cavalry, inexperienced and not acclimatized, were found, men and horses, so unfit for duty that he sent them to the rear. The pay of the army was three months in arrear, the supplies, brought up with difficulty, were very scanty —half and quarter rations were often served, sometimes the troops were without any bread for three days consecutively, and their clothing was so patched that scarcely a regiment could be known by its uniform. Chopped straw, the only forage, was very scarce, the regimental animals were dying of hunger, corn was rarely distributed save to the generals and staff, and even the horses of the artillery and the old cavalry suffered ;—the very mules of the commissariat were pinched and the muleteers eight months in arrears of pay. The cantonments about the Coa and Agueda were unhealthy from the rains, 20,000 men were in hospital, and after making deductions for other drains, only 54,000 of both nations, including garrisons and posts of communication, were under arms. To finish the picture, a sulky apathy in the Portuguese Regency was becoming more hurtful than the former active opposition. Yet these distresses Wellington with surprising subtlety turned to the advantage of his present designs ; for the enemy were aware of the misery in the army and their imagination magnified it ; and as the allied troops were scattered for relief from the Gata Mountains to the Douro, from the Agueda to the Mondego, immediately after the battering train entered Almeida, both armies concluded that the guns were to arm that fortress as a cover to the extended country quarters which necessity had forced upon the British general. Not even the engineers employed in the preparations knew more than that a siege or the simulation of a siege was in contemplation ; but when it was to be attempted, or that it would be attempted at all, none knew ;—even the Quartermaster-General, Murray, was suffered to go home on leave with the full persuasion that no operation would take place before spring.

In the new cantonments abundance of provisions and dry weather (for in Beira the first rains generally subside during December) stopped the sickness and restored 3,000 men to the ranks ; and the privations had in no manner weakened the moral courage of the troops. The old regiments were incredibly hardy and experienced in all things necessary to sustain their strength and efficiency, the staff was well practised ; and Lord Fitzroy Somerset, Military

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Secretary, had established such an intercourse between the head-quarters and the battalion chiefs that the latter had, so to speak, direct communication with the General-in-Chief upon all the business of their regiments, a privilege which stimulated the enthusiasm and zeal of all.

The favourable moment for action so long watched for by Wellington came at last. An Imperial decree had again remodelled the French armies. The army of the south was recomposed in six divisions of infantry and three of cavalry, exclusive of the garrison of Badajoz. Marshal Victor returned to France discontented, for he was one of those whose reputation had been abated by this war, and his divisions were given to eight generals and the younger Soult. The army of the north was exceedingly reduced in numbers, for the Imperial Guards, 17,000 strong, being required for the Russian War, marched in December to France. All the Polish battalions, the skeletons of the cavalry regiments, and several thousand choice men destined to fill the ranks of the Old Guard were drafted ; so that not less than 40,000 of the best soldiers were withdrawn, and the maimed and worn-out men being sent to France at the same time, the force in the Peninsula was diminished by 60,000 men. Marmont having been ordered to abandon the Valley of the Tagus and fix his head-quarters at Valladolid or Salamanca, Ciudad Rodrigo, the sixth and seventh governments, and the Asturias, were also placed under his authority. Montbrun being then near Valencia and Soult's attention distracted between Tarifa and Hill's pursuit of Drouet, the French were employed over an immense tract of country. Marmont also, deceived by the seemingly careless winter attitude of the Allies, left Rodrigo unprotected and Wellington instantly gave orders for the attack of the devoted fortress.

The Siege.

Thirty-five thousand men, cavalry included, were disposable for this enterprise. The materials for the siege were placed at Gallegos, Villa del Cierro, and Espeja, and the ammunition was at Almeida. From those places the hired carts and mules were to bring up the stores to the park ; 70 pieces of ordnance had been collected, but from the scarcity of transports only 38 guns could be brought to the trenches, and these would have wanted their due supply of ammunition, if 8,000 shot had not been found amidst the ruins of Almeida. A bridge was commenced the 1st January at Marialva near the confluence of the Azva with the Agueda, 6 miles below Ciudad, and to secure it piles were driven into the bed of the river above and below, to which the trestles were tied. The fortress was to have been invested on the 6th, but the native carters were two days moving over 10 miles of flat and excellent road with empty carts, and it was dangerous to find fault because they deserted on the slightest offence.

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When the place was closely examined, it was found that two convents which flanked and strengthened the bad Spanish entrenchments round the suburbs had been fortified; and on the greater Teson an enclosed and palisaded redoubt, called Francisco, was constructed and supported by two guns and a howitzer placed on the flat roof of a convent having the same name. All the ground was rocky except on the Tesons, and though the ramparts were there better covered by outworks and could fire more heavily on the trenches, it was, following the English general's views, most assailable, because elsewhere the batteries must have been placed on the edge of the counterscarp before they could see low enough to breach; this would have been a tedious process, whereas the smaller Teson furnished the means of striking over the crest of the glacis at once, and a deep gully offered cover for the mines. It was therefore resolved to storm Fort Francisco, form a lodgment there, open the first parallel along the greater Teson, place 33 pieces in counter-batteries to ruin the defences and drive the besieged from the convent of Francisco. Afterwards working forward by the sap, it was proposed to construct breaching batteries on the lesser Teson and blow in the counterscarp, while seven guns, battering a weak turret on the left, opened a second breach with a view to turn any retrenchment behind the principal breach.

Carlos d'España and Julian Sanchez were pushed to the Tornes in observation, while four British divisions and Pack's Portuguese laboured at the siege; but on the right bank of the Agueda there was neither fuel nor cover and the troops therefore kept their quarters on the hither bank, having, although a severe frost and fall of snow had set in, to ford the river each day by divisions in succession, carrying their provisions cooked. To obviate the difficulty of obtaining country transport the English general had previously constructed 800 carts drawn by horses, which were now his surest dependence for bringing up ammunition; and so many delays were anticipated from the irregularity of the native carters and muleteers and the chances of weather, that he calculated upon an operation of 24 days. Yet he hoped to steal this time from his adversaries.

On the 8th January the Light Division and Pack's Portuguese forded the Agueda 3 miles above the fortress, and making a circuit took post beyond the great Teson, where they remained quiet during the day, and as there was no regular investment the enemy did not think the siege was commenced. But in the evening the troops stood to their arms, and Colonel Colbourne, now commanding the 52nd, having assembled two companies from each of the British regiments of the Light Division stormed the redoubt of Francisco; this he did with so much fury that the assailants appeared to be at one and the same time, in the ditch, mounting the parapets, fighting on the top of the rampart, and forcing the gorge of the redoubt,

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where the explosion of one of the French shells had burst the gate open. Of the defenders a few were killed, not many, and the remainder, 40 in number, were made prisoners. When the post was thus taken with the loss of only 24 men and officers, Elder's Caçadores were sent to labour on the right of it because the fort itself was instantly covered with shot and shells from the town; this tempest continued during the night, but at daybreak the parallel, 600 yards in length, was sunk 3 ft. deep, the communication over the Teson was completed, and the siege advanced several days by this well-managed assault.

On the 9th the First Division took the trenches in hand, the place was encircled by posts to prevent any external communication, and at night 1,200 workmen commenced three counter-batteries for eleven guns each, under a heavy fire of shells and grape. Before daylight the labourers were under cover, and a ditch was also sunk in the front to provide earth for the batteries, which were made 18 ft. thick at top to resist the very powerful artillery of the place.

On the 10th the Fourth Division relieved the trenches and 1,000 men laboured, but in great peril, for the besieged had an abundance of ammunition and did not spare it. In the night the communication from the parallel to the batteries was opened, and on the 11th the Third Division undertook the siege. That day the magazines in the batteries were excavated and the approaches widened; but the enemy's fire was destructive, and the shells came so fast into the ditch in front of the batteries that the troops were withdrawn and the earth raised from the inside. Great damage was also sustained from salvos of shells with long fuzes, whose explosion cut away the parapets in a strange manner; and in the night the French brought a howitzer to the garden of the convent of Francisco with which they killed many men and wounded others.

On the 12th the Light Division resumed work, the riflemen profiting from a thick fog covered themselves in pits which they dug in front of the trenches and from thence picked off the enemy's gunners; yet the weather was so cold and the besieged shot so briskly that little progress was made.

The 13th the same causes impeded the labourers of the First Division. Scarcity of transport also baulked the operations. One-third only of the native carts had arrived and the drivers were very indolent; much of the 24-pound ammunition was still at Villa de Ponte, and intelligence arrived that Marmont was collecting his forces to succour the place. In this difficulty it was resolved to hasten the siege by opening a breach with the counter-batteries, which were not quite 600 yards from the curtain, and then to storm the place without blowing in the counterscarp; in other words to overstep the rules of science and sacrifice life rather than time, for the capricious Agueda might in one night flood and enable a small

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French force to relieve the place. The whole army was therefore brought up from the distant quarters and posted in the villages on the Coa ready to cross the Agueda and give battle.

In the night of the 13th the batteries were armed with 28 guns, the second parallel and the approaches were continued by the flying sap, and the Santa Cruz Convent was surprised by the Germans of the First Division, which secured the right flank of the trenches.

The 14th the enemy who had observed that the men in the trenches always went off in a disorderly manner on the approach of the relief, made a sally and overturned the gabions of the sap ; they even penetrated to the parallel, and were on the point of entering the batteries when a few of the workmen getting together checked them until a support arrived and the guns were saved. This affair, coupled with the death of the engineer on duty and the heavy fire from the town, delayed the opening of the breaching batteries ; yet at 4.30 in the evening 25 heavy guns battered the "*fausse braye*" and rampart, and two pieces were directed against the convent of Francisco. Then was beheld a spectacle at once fearful and sublime. The enemy replied to the assailant's fire with more than 50 pieces, the bellowing of 80 large guns shook the ground, far and wide, the smoke rested in heavy volumes upon the battlements of the place, the shells hissing through the air seemed fiery serpents leaping from the darkness, and the distant mountains faintly returned the sound. And when night put an end to this turmoil the quick clattering of musketry was heard like the pattering of hail after a peal of thunder, for the 40th Regiment then carried the convent of Francisco by storm and established itself in the suburb.

Next day the ramparts were again battered and fell so fast that it was judged expedient to commence the small breach at the turret; wherefore in the night five more guns were mounted. At daylight the besiegers' batteries recommenced, but at 8 o'clock a thick fog compelled them to desist ; nevertheless the small breach had been opened and the place was summoned but without effect. At night the parallel on the lower Teson was extended and a sharp musketry was directed from thence against the great breach ; the breaching battery as originally projected was also commenced, and the riflemen of the Light Division continued from their pits to pick off the enemy's gunners.

On the 17th the fire on both sides was very heavy, and though the wall of the place was much beaten down, several of the besiegers' guns were dismounted, their batteries injured, many men killed, General Borthwick, Commandant of Artillery, wounded, the sap entirely ruined, and the riflemen in the pits overpowered with grape ; yet towards evening the latter recovered the upper hand and the French could only fire from the more distant embrasures. In the night the battery intended for the lesser breach was armed and that on the lower Teson raised so as to afford cover in the daytime.

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On the 18th the besiegers' fire was resumed with great violence, the turret was shaken at the small breach, the large breach became practicable in the middle, and the enemy commenced retrenching it. The sap made no progress, the superintending engineer was badly wounded, and a 24-pounder, having burst in the batteries killed several men. In the night the battery on the lower Teson was improved, and a fieldpiece and howitzer being placed there kept up a constant fire on the great breach to destroy the French retrenchments. On the 19th both breaches became practicable, Major Sturgeon closely examined the place and a plan of attack was formed on his report; the assault was then ordered and the battering guns were turned against the artillery of the ramparts.

Assault of Ciudad Rodrigo.

This operation confided to the Third and Light Divisions and Pack's Portuguese, was organized in four parts.

1*st. Right Attack.*—A company of the 83rd and the Second Caçadores posted in some houses near the bridge were to cross the river and escalade an outwork in front of the castle where there was no ditch, but where two guns commanded the junction of the counterscarp with the body of the place. The 5th and 94th Regiments, posted behind the convent of Santa Cruz and having the 77th in reserve, were to enter the ditch at the extremity of the counterscarp, to escalade the "*fausse braye*" and scour it on their left as far as the great breach.

2*nd. Assault of the Great Breach.*—One hundred and eighty men, protected by the fire of the 83rd Regiment and carrying hay-bags to throw into the ditch, were to move out of the second parallel and to be followed by the storming party, which was again to be supported by Mackinnon's Brigade of the Third Division.

3*rd. Left Attack.*—The Light Division posted behind the convent of Francisco, was to send three rifle companies to scour the *fausse braye* to the right and so connect the left and centre attacks. At the same time a storming party, preceded by the Third Caçadores with hay-sacks and followed by Vandeleur's and Barnard's Brigades, was to make for the small breach, and when the *fausse braye* was carried to detach to their right in aid of the main assault, to their left to force a passage at the Salamanca Gate.

4*th. False Attack.*—This was an escalade to be made by Pack's Portuguese on the St. Jago Gate at the opposite side of the town.

Colonel O'Toole, of the Caçadores, commanded the right attack. Five hundred Volunteers, under Major Manners, of the 74th, the Forlorn Hope, under Lieut. Mackie, of the 88th, composed the storming party of the Third Division. Three hundred Volunteers, led by Major George Napier, of the 52nd, with a Forlorn Hope of 25 men

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under Lieut. Gurwood, of the same regiment, formed the storming party of the Light Division.

All the troops reached their posts without seeming to attract the attention of the enemy, but before the signal was given, and while Wellington, who in person had been pointing out the lesser breach to Major Napier, was still at the convent of Francisco, the attack on the right commenced and was instantly taken up along the whole line. Then the space between the troops and the ditch was at once covered with soldiers and ravaged by a tempest of grape from the ramparts. The storming parties of the Third Division jumped out of the parallel when the first shout arose, but so rapid had been the movements on their right, that before they could reach the ditch, Ridge, Dunkin, and Campbell, with the 5th, 77th, and 94th Regiments, had already scoured the *fausse braye*, and were pushing up the great breach amidst the bursting of shells, the whistling of grape and musketry and the shrill cries of the French, who were driven fighting behind the retrenchments. There they rallied, and aided by the musketry from the houses made hard battle for their post; neither side would give way, and yet the British could not get forward, and men and officers falling in heaps choked up the passage, which from minute to minute was raked with grape from two guns flanking the top of the breach at the distance of a few yards: thus striving and trampling alike upon the dead and the wounded these brave men maintained the combat.

On the left the stormers of the Light Division, who had 300 yards to clear would not wait for the hay-bags, but with extraordinary swiftness running to the crest of the glacis jumped down the scarp, a depth of 11 ft., and rushed up the *fausse braye* under a smashing discharge of grape and musketry. The ditch was dark and intricate, the Forlorn Hope inclined towards the left, the stormers went straight to the breach which was so narrow at the top that a gun placed across nearly barred the opening; there they were rejoined by the Forlorn Hope and the whole body rushed up, but the head of the mass crushed together as the ascent narrowed, staggered under the fire, and with the instinct of self-preservation snapped their own muskets though they had not been allowed to load. Major Napier struck by a grape shot fell at this moment with a shattered arm, but he called on the men to use their bayonets, and all the unwounded officers simultaneously sprung to the front, thus the required impulse was given and with a furious shout the breach was carried. Then the supporting regiments coming up in sections abreast gained the rampart, the 52nd wheeled to the left, the 43rd to the right, and the place was won.

During this contest, which lasted only a few minutes in the breach, the fighting at the great breach had continued with unabated violence; but when the stormers and the 43rd came pouring along the rampart

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towards that quarter the French wavered, three of their expense magazines exploded at the same moment, and then the Third Division with a mighty effort broke through the retrenchments. The garrison indeed fought for a moment in the streets, yet finally fled to the castle, where Lieut. Gurwood, who though severely wounded in the head had entered amongst the foremost at the lesser breach, received the Governor's sword.

Now into the streets plunged the assailants from all quarters, for O'Toole's attack was also successful, and at the other side of the town Pack's Portuguese, and the reserves meeting no resistance had entered. Throwing off the restraints of discipline the troops committed frightful excesses ; the town was fired in three or four places, the soldiers menaced their officers and shot each other ; many were killed in the market place, intoxication soon increased the tumult, and at last, the fury rising to absolute madness, a fire was wilfully lighted in the middle of the great magazine, by which the town would have been blown to atoms but for the energetic courage of some officers and a few soldiers who still preserved their senses. Three hundred French had fallen, 1,500 were made prisoners, and the immense stores of ammunition, with 150 pieces of artillery including the battering train of Marmont's Army, were captured. The Allies lost 1,200 men and 90 officers in the siege, of which 650 and 60 officers were slain or wounded at the breaches.

Generals Crauford and Mackinnon, the former an officer of great ability, were killed, and with them died many gallant men ; amongst others, a captain of the 45th, of whom it has been felicitously said that " three generals and seventy other officers had fallen, yet the soldiers fresh from the strife only talked of Hardyman." General Vandeleur, leading the Light Division after Crauford fell, was badly wounded, so was Colonel Colbourne and a crowd of inferior rank ; and unhappily the slaughter did not end with the battle, for the next day as the prisoners and their escort were marching out by the breach an accidental explosion took place and numbers of both were blown into the air.

To recompense an exploit so boldly undertaken and so gloriously finished Lord Wellington was created Duke of Ciudad Rodrigo by the Spaniards, Earl of Wellington by the English, Marquis of Torres Vedras by the Portuguese ; but it is to be remarked that the Prince Regent of Portugal had, previous to that period, displayed great ingratitude in the conferring of honours on the British officers.

Observations.

1st. This siege lasted only twelve days, half the time originally calculated upon by the English general. Owing to the heavy fire from the place the works were more slowly executed than might have been expected ; the cold also had impeded the labourers, but

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with a less severe frost the trenches would have been under water, because in open weather the water rises everywhere to within 6 in. of the surface. The worst obstacle was the disgraceful badness of the cutting tools furnished from the Storekeeper-General's Office in England, the profits of the contractor seemed to be the only thing respected; the engineers eagerly sought for French implements because the English tools were useless.

2nd. Wellington's audacity in storming the redoubt of Francisco, and breaking ground on the first night of the investment; his greater audacity in storming before the fire of the place had been even abated, or the counterscarp blown in were the true causes of the sudden fall of the place. Success depended more upon the courage of the troops than the skill of the engineer; and when the general terminated his order for the assault with this sentence, "Ciudad Rodrigo *must* be stormed this evening," he knew well that it would be nobly understood. Yet the French fought bravely on the breach, and by their side many British deserters, desperate men, were bayoneted.

3rd. A perpendicular descent of 16 ft. cut off the great breach from the town, and the bottom was planted with sharp spikes and strewn with live shells. The houses behind were loopholed and manned with musketeers, and on the flanks there were cuts, not very deep or wide, and the French had left the temporary bridges over them; but they had parapets so powerfully defended that it was said that the Third Division could never have carried them had not the Light Division taken the enemy in flank: an assertion perhaps easier made than proved.

4th. The neglect of the lesser breach was a great error. Narrow and high, a slight addition to its defences would have rendered it impracticable. Moreover the small breach was flanked at a short distance by a demi-bastion with a parapet which, though little injured, was abandoned the moment the head of the storming party forced its way on to the rampart. But the real defence of Ciudad was outside; when it fell Marmont's errors at Elbodon became manifest. Neither can that marshal be justified for having left so few men in Ciudad Rodrigo as with a garrison of 5,000 the place could never have been taken.

(To be continued).

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FENCE OF FORTIFIED PLACES.

CIUDAD RODRIGO, 1812.

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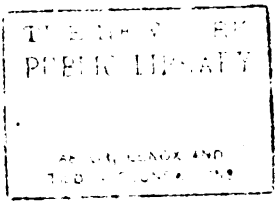
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TRANSCRIPTS.

HOW MANY DAYS WILL BE REQUIRED FOR THE CONCENTRATION OF THE GERMAN ARMY?

(Translation of extracts of an article in *Le Matin* by MONS. ADOLPHE GIROT, Secretaire de la Commission de l'Armée, dated 30th January, 1914).

THIS translation only deals with the German lines of advance on the portion of the frontier between Metz and Mulhaussen. Their arrangements generally are wonderfully complete and seem to make all possible provision for handling troop traffic as quickly as possible over these main routes. Station design and the general lay-out of the yards are invariably regulated with regard to possible military requirements. Money appears to be no object, and accommodation is usually much in excess of commercially justifiable peace conditions. For instance, fly overhead junctions, even for the smallest branch lines, are being put in presumably solely with a view to prevent delays in war time.

Route III. is especially well provided for—Neuenkirchen, an important junction, Saarbrucken in the coal district, Forbach, Benningen, Remilly, and of course Metz are all equipped for possible military purposes.

An article in the *Fortnightly Review* for February, 1914, gives an excellent idea of the rapid and methodical development in their strategic lines on the Belgian frontier for a possible advance through Holland and Belgium, and also *viâ* Luxembourg.

The discussion of the Three Years Law has resulted in numerous suppositions; some of them serious, others original, but all without foundation, on "l'attaque brusquée" and the necessary delays of a German invasion (of France). Other suppositions are not substantiated by military documents of any real value.

What will be the delay that will take place in the concentration of the attacking German Army? This is the crux of the question. As a matter of fact, it is on this delay depends the nature of the resistance and on it the time, date and character of "des grandes batailles."

Apart from the German "corps de couverture," which mobilize separately, following particular regulations and moving by special routes, and apart from the "Lanwehr" first and second reserves, whose duty it will be to observe the Danish frontiers, and apart from a certain number of units of the 1st, 2nd, 5th, 6th, and 17th Corps left on the Russian frontiers, the French "état major" know that Germany pro-

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posed two years ago, to concentrate on the French frontier "une masse de première attaque globale," having the following composition :—

Five army corps of 31 battalions	..	200,000 men.
Thirteen army corps of 25 battalions	..	450,000 ,,
Six divisions of cavalry of 24 squadrons	..	25,000 ,,
Seven divisions of Reserve of 16 battalions	..	125,000 ,,
Total	..	800,000 men.

In 1870 the Germans commenced main operations with 520,000 men. By reason of the rapid growth in effectives it is necessary to add 150,000 men to the total of 800,000, bringing L'Armée de Masse to actually 950,000 men. This total corresponds to the estimate given by Von der Goltz.

Nowadays the concentration of the armies of two large powers are like tremendous migrations. Each of them puts into movement more than a million men and hundreds of thousands of horses.

How are these millions brought into the battle position ? The study of the German railway system shows this.

Assuming that the neutrality of Belgium is respected, the front over which the concentration will take place is represented by the railway from Metz, southwards, *viâ* Sarrebourg, Zabern, Sshlestadt, Colmar, Mulhaussen : meeting the following ten independent lines of advance :—

Route I. (Ligne de l'Eifel).—Hamburg, Osnabrück, Munster, Essen, pont de Duisbourg, Cologne (Duren), Trèves, Thionville, Metz. It is a double track, but due to the grades in the Eifel Hills, its capacity is limited ; 20 trains in 24 hours.

Route II. (Ligne de la Moselle).—Berlin, Magdebourg, Paderhorn, Barmen, pont de Coblentz, Trèves, Bous, Courcelles. It is double track ; 40 trains.

Route III. (Ligne de la Nahe).—Berlin, Hanover, Dortmund, Duisbourg, pont de Cologne, Bingen, Neuenkirchen, Sarrebruck, Remilly. It is double track ; excellent capacity ; 50 trains.

Route IV.—Torgau, Leipzig, Erfurt, Bebra, Fulda, Hanau, pont de Mainz, Worms, Kaiserslauten, Sarrebruck, Sarreguemines. It is double track ; 40 trains.

Route V.—Dresden, Chemnitz, Bamberg, Nuremberg, Hall, Brüchsal, pont de Germersheim, Deux-Ponts, Sarreguemines, Berthelming. It is double track ; 40 trains.

Route VI.—Berlin, Cassel, Marbourg, Giessen, Frankfort, Darmstadt, pont de Mannheim, Neustadt, Landau, Haguenau, Zabern, Sarrebourg. Double track ; very good capacity ; 50 trains.

Route VII.—Würzbourg, Heidelberg, pont de Spire, Germersheim, Strasbourg, Rothau. Single track ; 20 trains.

Route VIII.—Ulm, Stuttgart, Carlsruhe, Rastatt, pont de Roschvoog, Hagenau, Obermodern, Sarralbe. Double track ; 50 trains.

Route IX. (Black Forest Line).—Passau, Ratisbon, Ingolstadt, Ulm, Sigmaringen, Tuttlingen, Willingen, Ofenbourg, pont de Kehl, Strasbourg, Molsheim. It is single track ; 20 trains.

Route X. (Swiss Frontier Line).—Munich, Memmingen, Stokach,

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Radolfzell, Weigen, Waldshut, Lovrach, pont de Mulheim, Mulhouse. Single track; 20 trains.

If the Germans violate the neutrality of Luxembourg, an eleventh route will be at their disposal, viz., Aix-la-Chapelle, Saint-Vith, Luxembourg, Thionville. It is a single track; 20 trains. It should also be mentioned, since it has been so clearly shown by Mons. Georges Leygues, that quite recently, in view of an advance by way of Belgium, numerous unloading platforms have been constructed at stations in the Eifel, and notably in the region of Cologne, Aix-la-Chapelle, Trèves. But this is quite apart from what is now under consideration, for in the case of an advance through Belgium, the railways of the north, instead of concentrating towards Metz, would unload their forces to the west of the Lower Meuse from Aix-la-Chapelle to Mezières. There would then be a pause in the final concentration due to the halting places that will be necessary when crossing Belgium, a large part of the troops coming from the north of Germany.

We now add the daily return of these 10 lines and we arrive at a total of 360 trains in 24 hours; a figure which is considered by the "état major" as a possible maximum. More probably, from hindrances, accidents, etc., there will be, say, 340 trains. If we now estimate, on an average, 130 trains to an army corps (the figure was 120 before the increases in establishments) and 45 trains to the new Reserve divisions, and 35 trains to the Cavalry Divisions, we find that the total transport required is 18 army corps ($18 \times 120 = 2{,}160$ trains; Reserve Divisions ($7 \times 45 = 315$ trains; Cavalry Divisions ($6 \times 35 = 210$ trains. Total, 2,685 trains.

Assuming a capacity of 340 trains per day, on an average, the moving of the army will take seven and a-half days.

Generally speaking "l'état major" allows that strategic movement can only commence on the evening of the third day. The result is that by the eleventh day, after the order for mobilization, the total German army "de grande bataille" would have reached the area of assembly.

And lastly, if one assumes a delay of two more days to allow the rear corps to come up to their allotted places in the ranks, we see that the army would be ready to march on the thirteenth day.

Looking back to 1870, the German mobilization lasted from the 16th to the 23rd July. The concentration was completed on the 1st August (14 days), Wissembourg took place on 4th August, and on the 6th the Battles of Frœschwiller and Wœrth were fought. Twenty days had passed from the beginning of mobilization to the first encounter.

Finally let me quote a sentence from the "cours supérieur":—"Le réseau ferré militaire français est au moins aussi riche que le réseau allemand."

Nothing proves then decisively that the first operations of the next war between France and Germany will take place in French territory.

A. H. L. MOUNT.

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THE SIEGE OF ADRIANOPLE.

From an article by V. N. POLYANSKI in the September, 1913, and subsequent numbers of *Injenerni Jurnal*.

CHAPTER I.

THE FORTRESS AND ITS EQUIPMENT.

THE materials for this account of the Siege of Adrianople were collected by the author during a visit to the theatre of war in Thrace in the spring of 1913.

Adrianople.

Adrianople, called by the Bulgarians Odrin, and by the Turks Edirne, was the capital city of the Osmans from 1363 up to the capture of Constantinople in 1453, after which it became the chief city of the Adrianople vilayet and the second capital of modern Turkey. It is situated at the confluence of the rivers Tunja and Maritza, and about 2 miles above the junction of the Arda with the Maritza.

The town rests in a hollow surrounded by hills on all sides, except on the south-west, where is the valley of the Arda. Its narrow, crooked streets with overhanging balconies, its large many-coloured bazaars, its numerous mosques, among which that of Sultan Selim is easily recognized by its four minarets, give it a typical eastern character. A traveller approaching the town from any direction will see the high minarets of Selim from a distance of 8 or 9 miles, and these made excellent observation posts for the Turks during the siege. The columns and the dark cypresses, the invariable adjuncts of mosques, give to the town the characteristic appearance of all towns of Southern Turkey.

The population of the town and neighbourhood is a mixture of Mussalmans and Christians, the former, Turks, predominating over the latter, Greeks and Bulgarians, and there are also Jews and Armenians. In peace time the town has a population of 80,000, but during the siege this was increased to 100,000, by the Turks who crowded in from the neighbouring villages.

At 1¾ miles to the south-west, on the far side of the Maritza, lies the large suburb of Karagach, which is connected with Adrianople by a fine road with stone bridges over the Maritza and Tunja. Here is the railway station on the Sophia-Constantinople Railway. Its population consists of wealthy Greeks who live in fine well-built houses with orchards and flower gardens. The streets are wide and well kept.

There are no woods in the neighbourhood of Adrianople. In places there are isolated trees and on the river banks small groves and bushes.

On the right bank of the Tunja there is the Greek suburb of Hedirlik, and about 1,000 yards to the north of this the Turks have built the spacious barracks of Yanlik-Kashli for the accommodation of the garrison in peace time.

Strategic Value.

As the key to Constantinople, Adrianople has great strategic importance. The theatre of war in Thrace is very poorly provided

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with roads, and here all the lines of communication meet. These include:—(1), The Vienna-Belgrade-Sophia-Constantinople Railway; (2), the Sophia-Constantinople main road; (3), the main road from Adrianople to Kirk Kilisse (called by the Bulgarians Lozengrade); the unmetalled roads from the Balkans to the shores of the Ægean Sea (Dedergach and Kavala) and to the Sea of Marmora (Rodosto and Silivria). From here also the Maritza is navigable to its mouth.

In addition to this, being fortified, Adrianople forms a pivot of manœuvre for the Turkish field armies, and may be used either as a base for offensive operations against Bulgaria, or as a support for the left flank of the Adrianople-Kirk Kilisse defensive line.

Furthermore, if its religious and political importance, as the second capital of Turkey, be taken into consideration, the prominent part which it was expected to play in the late war will be understood.

Fortification.

There is no doubt that the Turks recognized the importance of Adrianople, and they should certainly have taken all measures to make it into a first-class manœuvre fortress, calculated to withstand for a long period all forms of assault. But it will be seen later that at the time of its siege by the allied troops it was by no means an up-to-date manœuvre fortress. It was at best but a position of temporary character.

A project for the renovation of the fortress was prepared by the German instructors, and had been approved by von der Goltz-Pasha, but even if the Turkish engineers had shown more conscientious attention to their duties than had been the case, its recommendations could not have been completed for several years.

Adrianople had been fortified from the earliest times. At the time of the Russo-Turkish War of 1877–78 its fortifications consisted of a belt of 24 temporary battery-forts. These were nearly all of one type; their distance from the town varied from 600 yards to 3¼ miles, and their intervals from one another from ½ to 2¼ miles. The main ramparts of these works were arranged for artillery, in places in tiers. The glacis and covered ways formed the infantry positions. The guns were separated by traverses, in which there were casemates constructed of timber. The ditches were undefended and gorge parapets were often omitted. The escarps and counterscarps were of earth, standing at the natural slopes. The entrances were screened by semi-circular ramparts not prepared for defence, and no fire could be brought to bear towards the rear. There were no works in the intervals between these forts.

The defences remained in the same state up to 1885 when the Turks commenced to remodel these old forts. The reconstruction consisted only in replacing by brickwork the timber in the casemates, and in building brick barracks in the works. The remodelled forts, or as the Bulgarians called them "permanent redoubts," had ramparts 8 to 11½ ft. in height, parapets 19 to 28 ft. in thickness, ditches 40 ft. wide and 13 ft. deep, without any defence, and the thickness of the brick arches of the casemates was about 3 ft. No attention had been paid to the concealment of these works.

Adrianople again attracted the attention of the Turks in 1908, and then the German project was prepared and the works contemplated in it were commenced.

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Bulgarian Information.

According to the information which had been collected for the Bulgarians by their agents, "the manœuvre fortress of Odrin" in 1911 consisted of a ring of 30 permanent redoubts, 26 of which were old, and four new, of which one was built of concrete. The new redoubts were protected by wire entanglements. In the intervals, there were rifle trenches with covered communications to the rear. Altogether 74 batteries had been counted on the positions, of which eight were permanent and built of concrete. The rest were temporary, made of earth with light blindages. The magazines were some of brick and some of timber, and some concrete ones were in course of construction. On some of the fronts advanced positions had been trengthened with fieldworks, consisting of trenches and redoubts.

From all the data thus obtained plans of the fortress had been prepared, and these were frequently revised. Finally on 1st July, 1911, a very detailed and fairly accurate map of all the fortress works was made to a scale of $\frac{1}{20000}$ with 5-metre contours. It was estimated that the number of the garrison would be 45,000, and that there would be in the fortress 192 guns of large calibres and from 320 to 325 field guns.

The information obtained by the Bulgarians appears to have been fairly accurate, except as regards the number of the garrison, which turned out to be greater, and the strength of the new works, which was less, than they supposed. This reacted upon the resolution of the operations during the first period of the siege (up to the armistice), and required a fresh detailed reconnaissance which resulted in the attack by assault, a system fully suited to the existing conditions.

Details of Fortification.

Passing now to a detailed description of the defensive positions as they actually existed during the siege (see map), it will be seen that the hills which surround the town on north and east are offshoots from the Balkans, and those on south and west branches of the Rhodope Mountains. The slopes are fairly gradual, the eastern slopes of the ridge forming the so-called east front being the steepest and falling at angles of from 25° to 30°.

The ridges surrounding the town form natural positions for defence. The reverse slopes towards the town are gradual, and are completely hidden from outside observation. The confluence of three rivers within the fortress area is favourable to the defence, as with plenty of permanent bridges troops can be thrown rapidly from one front to another. The conditions are incomparably worse for the attack, the rivers hindering communication between the various sectors; the construction of crossings is made difficult by the rapid currents and by the width of the rivers, which in rainy weather soon overflow their banks and become rushing torrents, quickly washing away light bridges. The separate hill masses, divided by the open impassable river valleys, make it possible to organize separate defensive groups, well linked together by mutual fire support.

A number of tumuli—old graves—form an excellent system of observation posts. The absence of vegetation along the front and the comparatively gradual fall of the ground, make fields of view and fire alike good.

The soil is clay, easy to work and allowing very steep slopes in

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excavations. In fact, the conditions are in the highest degree favourable to defence, and these in conjunction with the abundance of materials—large city, groves and orchards—should have made it possible for an energetic commander (which Shukri-Pasha, unmeritedly entitled Ghazi, or "Invincible," certainly was not) to show a very resolute resistance, in spite of the unfinished condition of the defence works.

The perimeter is divided by the rivers into four "sectors" or "fronts":—

(1). The North-West Front, between the right bank of the Tunja and the left of the Maritza. The N.W. Front.

This front was the strongest. The positions formed two sections, right and left. The right section, or North Front, consisted of a group of two forts, some rifle trenches and 10 batteries, of which four were armed with heavy guns (12 and 15-c.m.). The group was sited on the hill Karagioz-Tarla, about 4¼ miles from the town.

The forts, Yeshil-Tepe (1) and Yasi-Tepe (2), were of temporary profiles with glacis-shaped parapets; under the parapets of their front faces there were blindages of light construction, giving protection against shrapnel and splinters.

The work on these forts was still in the initial stage, and the earthwork had been completed only on the front face and part of the flanks, so that the works were really lunettes. The yellowish-whitish earth of the parapets showed up brightly against the surrounding ground and was visible from a great distance. The rifle trenches were successfully applied to the ground and well disguised and were evidently the main positions of defence. In front of the whole group, at 50 paces from the forts, a wire entanglement was erected, with metal posts and about 29 ft. in width. This was the normal width of the entanglements at Adrianople, the posts were of angle iron or wood, fastened into metal plates, and from 3¼ to 4 and 5¼ ft. in height. The distance apart of posts was from 5 to 6½ ft., of rows, from 6½ to nearly 10 ft.; the wire was barbed.

At 1,100 yards in rear of the forts was the sector magazine built of concrete. Besides this there were in rear of the batteries magazines built of timber, or roofed with semi-circular corrugated iron, giving protection only from splinters and the weather.

In front of the Karagioz-Tarla group, at about 1¼ miles to the north, was an advanced position on the hill Uch-Tepeler, consisting of groups of rifle trenches, with communication trenches, and dug-outs on the reverse slopes.

The left section of the North-West Front was a low ridge with an excellent field of fire up to extreme ranges, and with the rear concealed from the enemy's view, allowing the skilful siting of batteries, which had been well done by the Germans. The main position of defence had been sited on this ridge and consisted of 3 forts and 27 batteries, with rifle trenches in the intervals.

An uninterrupted belt of wire entanglement had been drawn across the whole front from the Tunja to the Maritza.

The fort on the right flank of this section, Shaitan-Tarla, otherwise Karagoz-Tabiya (3), sited on the hill of that name, was the

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strongest of the whole fortress. It was a closed work of old construction with high ramparts and brick casemated traverses. The rifle positions were on the glacis with a wire entanglement in front. The gorge glacis was also prepared for defence but without an entanglement.

On each side of the work, where there were formerly batteries, concrete barracks had been built, of a type similar to that of the main magazine. In these barracks there was accommodation for two companies of infantry (see *Fig.* 1).

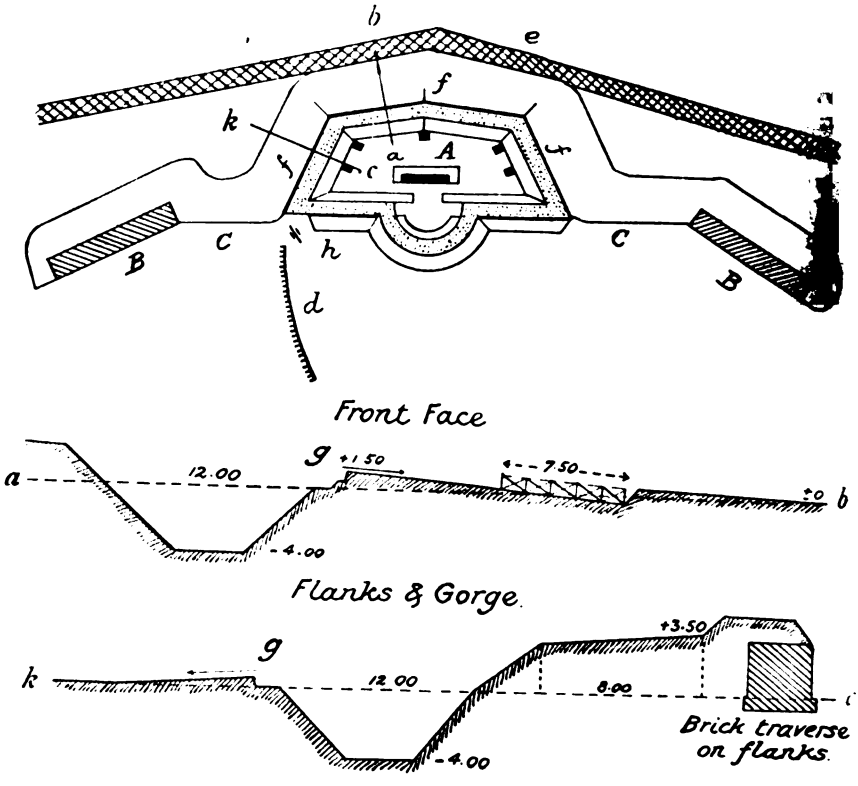

FIG. 1.—*Plan of the Shaitan-Tarla Group.*

A.—Fort Karagoz-Tabiya.
B.—Concrete Barracks.
C.—Communication Trenches.
d.—Rifle Trench.
e.—Obstacle.
f.—Firing Line.
g.—Rifle Positions.
h.—Gun for Opposing Assaults.

Measurements in Metres.

At 1¾ miles to the south of Shaitan-Tarla was the Fort Kazan-Tepe, (4), sited on a hill with a very good all-round command. This was a semi-permanent lunette, of glacis-shaped profile, with an entanglement, defended by frontal fire, and under the parapet concrete recesses for the men, giving overhead protection against splinters and shrapnel and common shells of field calibres. Within the fort were barracks built of stone in cement, the rear walls being of concrete. With gorge protection, this would have been the strongest work in the

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fortress, but as there was none, the work could have been turned and easily captured, and had no value as a strong point.

The third fort of this section, Kazan-Kiupriu (5), was within ½ mile of Kazan-Tepe. It had no fighting value as it had been but lately begun and consisted only of a formless mass of earth.

The whole strength of the North-West Sector lay in the well-organized preparation of the intervals with fieldworks. Here were rifle trenches well sited and carefully disguised, which mutually commanded the approaches to one another and flanked sections of the wire entanglement. In rear of these, at 160 to 220 yards' distance, there were batteries, also well sited in concealed positions. Some of these were permanent, built of concrete, armed with 15-c.m. long guns and 21-c.m. mortars, on overbank mountings arranged for all-round fire, which gave them a very large sphere of action, for owing to the small diameter of the fortress they could fire with effect over the town in support of other sections. The concrete roofs of the traverses were less than 18 in. in thickness, and were demolished by single hits from the 15-c.m. howitzers of the most modern type, which the Servians possessed. In addition to this the batteries were very badly built and were damaged by the firing of their own guns, cracks appeared in the roofs, foundations gave way, and the concrete revetments of the parapets were destroyed. In this section of the North-West Front there were two concrete magazines, and several lighter ones.

In front of the main position, advanced positions, fortified with fieldworks, were prepared at the village Kidin-Keui and at the farm Yekmekchi-Keui. These consisted of series of rifle trenches and field batteries.

The main front of this sector, with the exception of Fort Karagoz-Tepe, had been begun since 1908 and was intended to keep the artillery of the attack at a distance from the town. In this it was only partially successful, as Kazan-Tepe was only about 5,500 yards from the town. The advanced positions were occupied to reduce this defect and effectively fulfilled their object.

In rear of the main position there was a second line of defence, consisting of three old forts :—Bash-Yiuk-Tepe (6), Kemer-Tepe (7), and Ainali-Tepe (8), and of several batteries of temporary character. The batteries were sited in front on the north side, in order to command the interval, of about 3,200 yards, between the Karagioz-Tarla and Shaitan-Tarla groups. Lastly, as a keep to the whole sector, there is the old, unaltered, but well-preserved, Fort Hedirlik (9), sited on a hill at about 1,600 yards from the town, near the suburb of that name.

In Fort Hedirlik, in spacious brick barracks, the Commandant Shukri-Pasha lived with his staff. Here also was the station of the wireless telegraph which worked with Constantinople.

This sector was considered as the most probable one to be chosen for attack. The ground favours the siting of siege batteries, and the most suitable road for the transport of siege materials runs through it from the Bulgarian frontier. For this reason the Turks (and Germans) paid most attention to it, and in it began their work of reconstruction of the fortress.

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In criticism of this sector, it must be admitted that the *tactical* problem had been well met, the sites for the strong points were well chosen, the fortified groups well linked together by their fire, the batteries well sited. The three separate advanced positions were supported by fire from the main position, while in their turn they enfiladed the approaches to the forts and served as pivots of manœuvre for the active action of the garrison in this direction.

But *technically* the solution was unsatisfactory. The strong points were unfinished and were by no means forts in the real sense of the word. The writer suggests that they belonged to a German type of works "insecure against assault," as they were deficient in all-round fire and all-round obstacles, had no permanent obstacles, no defence of ditches, no cover in the rampart to protect the men from the fire of guns of large calibres, and were unprovided with casemated defence of the intervals between them.

As rifle positions they were unsuitable, as they were badly concealed, had narrow fronts, of from 100 to 150 yards, little area, and no defensible casemates. In no case could firing from them be maintained during an artillery bombardment, and their only value during the siege was that the concrete barracks gave protection against the 15-c.m. howitzers of the attack. As they were unable to protect the intervals between them, their military value was *nil.*

The permanent batteries in the intervals were technically unworthy of criticism, owing to the weakness of their casemates, and their inability to withstand the effects even of their own fire.

The defences of the intervals utterly failed to satisfy the requirements of permanent fortifications. They were purely fieldworks, but since the trenches were very well sited and of well-chosen types—many without parapets—the intervals had great strength as fire positions and were little damaged by artillery fire. The whole defensive strength of the sector rested in the intervals.

The continuous line of wire entanglement across the whole front of the sector was a grave technical error. It precluded any possibility of sorties, cut off the advanced positions from support, and doomed the defence to a purely passive course of action.

The best of the other works were the concrete magazines and the fine development of roads and narrow-gauge railways.

The W. Front.

(II.). The West Front, between the left bank of the Arda and the right of the Maritza, consists of a mass of hills stretching from east to west, shaped in a triangle, of which the apex rests on the village Marash, the point of confluence of the two rivers. A series of separate summits with flat tops and steep sides commands the valleys. The hill named Papas-Tepe is tactically the most important, and from this all the positions of the West Front were named.

The position is naturally very strong. The flanks consist of steep slopes and are protected by the rivers. The considerable width of front allows of the development of strong frontal fire, and the series of ridges allows of the development of the defence in depth. In the folds of the ground there is natural cover for reserves and batteries.

As it is about 6 miles from the town, and stands out in front of the

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general line of the adjacent North-West and South Sectors, this sector forms a kind of caponier, commanding the approaches to its neighbours, while in their turn the batteries of the adjacent sectors command the approaches to Papas-Tepe. If an attack succeeded in capturing this mass it would obtain an excellent observation post, with a superb view of the town, the rear of the North-West Front, the suburb of Karagach with the railway station, and the whole of the south, low-lying front. The main and advanced positions of the adjacent sectors would also be commanded. But, although strong, it would be difficult to hold, as its comparatively narrow ridge would be swept by cross-fire from the batteries of the adjacent sectors.

From an engineering point of view the Papas-Tepe defences were entirely fieldworks. The most important item was a strong point, the only one of the kind in the fortress, consisting of a system of fire trenches, for one battalion, with fire in all directions, communication trenches, dug-out shelters on reverse slopes, and an entanglement protecting it on all sides.

This strong point was sited on the hill Papas-Tepe. In front of it, at about 1,000 yards to the west, on "Tomb" Hill, and on other hills in its neighbourhood, there were rifle trenches for about a regiment of infantry, and on the east of Papas-Tepe, on the hill Bekchi-Tepe, there were more trenches which served as a keep to the whole group.

In order to protect the flanks of the group from being turned from the direction of the river valleys the Turks had made trenches on the hillsides and extended them on one side to the Arda and on the other to the Maritza.

Two batteries of 12-c.m. field howitzers were well concealed and entrenched in folds of the ground, near the strong point. The tomb was converted into an observation post.

From this it will be recognized that the defences of the West Front were purely fieldworks, but they had considerable strength.

III. The *South Front*, between the right bank of the Maritza and the right of the Arda, is generally level. From the river valleys, near Karagach, the ground gradually rises towards the south-west, forming a low plateau. At 4½ to 5 miles from the suburb the hills begin, a branch of the Balkans, of which the highest is named Kartal-Tepe. The S. Front.

Near Karagach the ground is completely open, only the valley of the Maritza is hidden by copses and low jungle.

The somewhat wavy character of the plateau makes it possible so to site batteries in its folds, that even if the flashes of the guns are seen by the attacking troops, it is difficult to locate them accurately in any one of a series of such depressions.

The main position consists of a line of four old forts and 13 batteries. In the Maritza valley, at the village of Bosna-Keui, there is a fort of that name (10). At 2,000 yards from this village, at the village of Demirdesh, there is a fort of that name (11). At 3,200 yards beyond, near the suburb itself, is Fort Karagach (12), and at 1,000 yards from the latter is Fort Marash (13) on the right flank of this sector.

Between Forts Demirdesh and Karagach, near the railway embank-

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ment there is, besides, an old dismantled fort, named Markez-Tibiya (14).

All these forts are old and of the 1885 reconstructed type, already described. In the 1908 project the Turks intended to make a new line of forts further to the south, in order to hold off the artillery of the attack from Karagach and the railway station. Permanent batteries were also to have been sited in the intervals between and to the rear of the new forts. The work of carrying out the recommendations of the project was begun, by German advice, by making these batteries, which consequently were *in front* of the existing fort line.

These batteries were partly of concrete and partly of temporary construction, and the magazines were only of temporary construction. In order to protect them it had been necessary to make rifle trenches, with a redoubt on the left flank (at about 160 yards from the batteries), and to stretch a wire entanglement from the Maritza to the Arda. Besides this, the following advanced positions, at distances of 5,500 to 7,000 yards from the batteries, were occupied and entrenched :—Pamuk-Sirti, Kartal-Tepe and Daudjaros (near the village of that name). All these positions were strengthened by fieldworks during the siege. The Turks held out in them for five months, and they formed strictly speaking the main defensive positions of the South Front.

The South Front position was also, therefore, mainly one of field character, and the wire obstacles were to a great extent *behind* it.

The advanced positions were correctly selected in accordance with local conditions, but the fortress batteries were too far to the rear and could not well support the infantry positions.

The N.E. Front.

IV. The North-East Front, between the left bank of the Tunja and the left of the Maritza, was in its turn divided into two sections, north and east.

The north section begins at the Tunja and extends to the ruins of the former village Arnaut-Keui. It is linked by fire with the Karagioz-Tarla group of the North-West Sector, and is naturally divided by the river Provadiiska into a plain and a hill section. The plain section was considered by the Turks as liable to be pierced by the attack, and was fortified fairly strongly. Between the Tunja and the Provadiiska, on the height of the Deptli-Mustapha bridge, spanning the Tunja, there were rifle trenches of full profile (*i.e.* with a covered way behind the firing step), with overhead protection against shrapnel bullets ; at 1,000 yards to the front, on a ridge to the north of the Provadiiska, was another line of trenches. This front line was strengthened with automatic mines (weight of charge about 10 lbs., fired by means of friction tubes when trodden on), 30 in number, laid in a single line from the Tunja to the Provadiiska.

The second line was strengthened by a wire entanglement which stretched from the Tunja through the whole plain section to the foot of the hill, on which was placed Fort Koyalik (15), with adjoining batteries, armed with non-quick-firing field guns. The fort is of old construction, badly concealed, its high rampart showing up sharply on the hill. The hill slopes are steep and consequently there is dead ground at their foot.

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In order to strengthen this fort the Turks dammed the Provadiiska, and made an unfordable inundation in front of it. Besides this, they extended the wire entanglement still further. The position thus obtained was very strong in front and its flanks were protected, the left by trenches on the low ground, sited in échelon backwards, and the right by the neighbouring group of the hill section, Kurt-Kaya, which flanks the approaches to Koyalik.

This Kurt-Kaya group consists of a mass of hills rising to 285 ft. above the valley of the river, and contained two forts, the old Tash-Tabiya (16) and the new Tash-Tabiya (17), with groups of rifle trenches and a few batteries.

The new Tash-Tabiya was a lunette battery of the eighties, with brick casemated traverses, but the guns had been removed. Within the fort there were large brick barracks for the accommodation of the garrison. Old Tash-Tabiya was a dismantled redoubt of the seventies, and lay at about 1,000 yards in rear of the other.

Once more, the strength of the group lay in the rifle trenches, which were well applied to the ground. Their profile was for firing standing, and they had traverses, but cover from shrapnel fire was non-existent.

From Fort Tash-Tabiya, across the whole North-East Front, right up to the Constantinople road, there ran a continuous belt of wire entanglement. Some of the rifle trenches had been pushed forward, and these had the wire obstacle behind them !

In second line, in the north section of this front, at a distance of about 3,200 yards, there were two old forts of the seventies :—Bashi-Tak-Tabiya (18) and Tashlik-Alti-Tabiya (19).

On the reverse slopes of the hills on which the forts were built there were temporary magazines.

Next to Tash-Tabiya stands Fort Aivas-Baba (20) in the salient angle formed by the north and east sections of the North-East Front. The angle is nearly a right angle, and the facility which it afforded of enfilading both fronts was not overlooked by the Bulgarians. The distance of the north section from the town is from 5,500 to 6,000 yards. From Aivas-Baba the fort line runs due south, approaching the town, from which the nearest fort is less than 1 mile distant.

The East Front occupies a sharply marked ridge, with gradual slopes towards the town and steeper ones (25° to 30°) eastwards, towards the valley in which runs the town water supply.

By its local conditions this is a very strong position. The ridge has a command over the approaches of 330 to 400 ft., and has splendid fields of view and fire. There is some dead ground, but its extent is insignificant, at the village Hassan-Aga in the Provadiiska valley. There are splendid concealed positions for artillery, and for communication with the rear, and the movement of reserves can be carried out in complete concealment from the enemy's view.

The fault of this position is the sharp outline of its crest, which facilitates the ranging of hostile artillery. This will be made very evident in the description of the fighting, and here no more need be said about it.

The ridge had been very badly fortified. In front line there were seven forts, 21 batteries, and a limited number of rifle trenches.

The forts, in the order of their siting from the salient angle, were named

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as follows :—Aivas-Baba (20), Aidji-Yolu (21), Kestenelik (22), Kuru-Cheshmi (23), Yildiz (24), Top-Yolu (25), and Kavkaz (26). In the second line was Fort Kaik (27) built on a hill within the town.

All these forts were of old construction, remodelled in 1885, and from that time left without any alteration or repair. The remodelling, I would remind the reader, consisted only in providing brick casemates. (Although these roofs were of 3-ft. brickwork with 4¾ ft. of earth on the top, they were pierced by single 12-c.m. and 15-c.m. shells). The rifle positions were the glacis and covered ways, or ordinary fire trenches in front. In the covered ways, in rear of the glacis, there were in places traverses of sandbags, but there was usually no protection from shrapnel fire, from which in course of time the Turks received cruel punishment. Some of the forts had ditches, which were quite useless, as they were not swept by fire and presented no obstacles to assault. Fort Aivas-Baba had no ditch, but it had an old reduit, which was, however, not prepared as a firing line.

In order to give an idea of the construction of the " forts " of the East Front a sketch is given of Fort Aivas-Baba, which formed the main objective of the assault on March 24th—26th, 1913 (see *Fig.* 2). All the forts of the East Front had high ramparts (11½ ft.) above which the casemated traverses rose another 4 ft. The distances between forts were on an average about 1,000 yards.

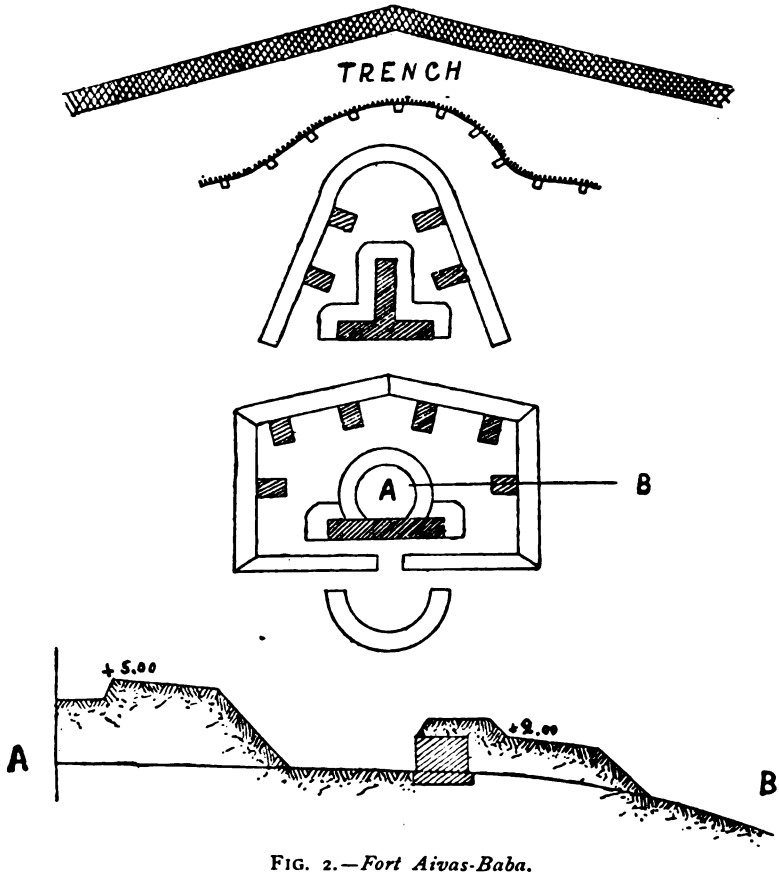

FIG. 2.—*Fort Aivas-Baba.*

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The fortress batteries of the East Front were placed between the forts, in line with them, on the same ridge. The sites were exposed, and clearly seen from the front in spite of attempts at concealment. Only two batteries, one of 15-c.m. howitzers of new type and the other of mortars, were well applied to the ground in concealed positions.

The majority of the guns of large calibre had overbank mountings. The batteries were of temporary type with blindages of timber or corrugated iron, giving protection from splinters and shrapnel bullets.

As the batteries stood on the top of the ridge there was under them about 1,500 to 2,000 yards of dead ground, so that they could not be used in opposing an assault; they were also unsuitable for engaging the well-concealed batteries of the attack.

The batteries had magazines of timber, and the group magazines were of similar construction. At 2,000 yards behind Fort Yildiz, in a deep ravine, there were old brick magazines for the batteries of the whole sector.

The intervals between the forts were badly prepared. The trenches on the heights were unsatisfactorily disguised and they had no cover from overhead fire. And yet in this sector the trenches proved themselves the most important works, and offered the greatest resistance to the attack during the assault.

As the forts were so near to the town, the Turks fortified advanced positions on the ridge which began on the height Kara-Bair, through Maslak, Sapupjilar, Eski-Kumluk, to Demir-Kapu, inclusive, where ran the Constantinople main road. The distance of these positions from the main front is from 1,000 to 4,500 yards. Between Demir-Kapu and Fort Kavkaz another intermediate position was fortified on the Helvadji Heights.

These positions were fortified with fieldworks and included rifle trenches of various profiles, communication trenches, dug-outs on reverse slopes and field batteries.

Some of the trenches had the shape on plan of half-closed works, but they were certainly not redoubts, though in the Bulgarian map there is a redoubt shown in the Maslak group.

The advanced positions were separated from the main front by a valley and by a continous line of wire entanglement, which proved fatal to the Turks during the assault.

Thus the North-East Front, strong naturally, was very badly fortified. The Turks had endeavoured to reduce the defects of the main position by the construction of advanced positions, but the latter were weakly fortified, had no cover from artillery fire, and most serious of all, were not far enough away (*e.g.*, Maslak, on the left flank), so that the artillery of the attack without changing position could act effectively against both the advanced and main positions.

The advanced positions received a certain amount of support from the main position by artillery fire, but the infantry could not support them at the right moment as they were separated from them by the entanglement, while their defenders were unable to retire in time.

The advanced positions were of some use in hindering the artillery of the attack from bringing effective fire to bear upon the town, but the long-range guns could throw shells into it.

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In any case the Turks should have left the main position and should have carried the whole centre of gravity of the defence to the advanced positions, which should have been more strongly fortified. But Shukri-Pasha, thinking that he had "forts," which turned out to be only shell traps and tombs for his men, took half measures, defending both the advanced positions and the main front weakly, and suffered complete destruction.

This completes the description of the fortress defences.

Recapitulation. Reviewing the whole it may be said that the North-West Sector was the newest and at the same time the strongest. Its strength lay in the favourable conditions of the ground, in its strong and well-sited artillery, in the presence of a small number of solid concrete shelters—barracks and magazines—and chiefly, and this was the case in the whole fortress perimeter, in the well-sited rifle trenches, and in the well-developed network of roads. Besides this the works of the second line and the Hedirlik reduit could co-operate in rendering the defence resolute.

The weakness of this front, as of all, was the want of strong points, proof against assault.

The West Front (the Papas-Tepe group) was strong by conditions of the ground and well fortified with *fieldworks;* the same may be said of the South Front. As regards the North-East Front, notwithstanding its favourable local conditions, owing to a whole series of tactical and technical blunders, it was the weakest.

The most serious technical faults were *the absence of light cover from shrapnel bullets and the misuse of wire obstacles.*

Garrison. In peace time, before the war, the garrison of Adrianople consisted of an army corps of two divisions, with a corresponding quantity of artillery, cavalry, engineers and subsidiary troops. The total number reached 25,000 men. For the siege, the cadres were filled up, and besides this the Bulgarian staff obtained information that the following troops of the 4th Army Corps had been added to the garrison :—

10th Infantry Division—28th, 29th and 30th Infantry Regiments (each of 3 battalions), the 10th Rifle Battalion, 10th Q.F. Artillery Regiment. Total, 10 battalions and 24 guns.

11th Infantry Division—14th, 32nd and 33rd Infantry Regiments, 11th Rifle Battalion, 11th Q.F. Artillery Regiment. Total, 10 battalions and 24 guns.

The 4th Rifle Regiment—4 Battalions.

Redif Divisions—The Adrianople Division, with the 1st division of the 9th Q.F. Artillery Regiment. Total, 10 battalions and 12 guns.

The Baba-Eski Division, 14 battalions.

The Gumurdjina Division, with the 1st division, 12th Q.F. Artillery Regiment, and 1 mountain division, 10 battalions and 24 guns.

The 12th Cavalry Regiment and part of the 2nd Cavalry Regiment, 6 squadrons. (The report of correspondents concealed in the fortress that after the Battle of Kirk-Killisse there were 40 squadrons, appears to be incorrect).

5 Fortress artillery regiments.

5 Machine-gun companies, and engineers.

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Total, 58 battalions of infantry, 84 q.f. guns, 5 artillery regiments, 6 squadrons, engineers and subsidiary troops.

If a company is taken as 200 men, the total of the garrison according to this estimate would be about 50,000 to 55,000 men. But according to the information of the Bulgarian headquarters 60,000 prisoners were taken of the rank and file alone, so that taking into consideration losses, the total number of the garrison must be estimated at not less than 75,000 men. It is true that this probably includes a number of forcibly impressed Christians from the surrounding villages, who were serving with the Turkish train. At the head was the Commandant of the Fortress, Shukri-Pasha, who in the opinion of those who knew him was an upright man, but weak in character. The Wali, or governor of Adrianople, had great influence over him, persuading him to act with greater energy.

Equipment.

The garrison were well equipped with everything necessary, clothing of a protective colour, boots, and their fezes instead of the traditional red were also of protective colour. A want of warm clothing was experienced, and consequently in the cold weather the soldiers put on anything they could find. This probably explains the quantities of all kinds of rags with which all the Turkish positions were littered.

The officers were well and even smartly clothed. In their case the fez had been replaced by special caps like grey Cossack fur caps.

Armament.

The Armament of the Infantry.—The Nizam and Redif (European corps) had the 7·65-m.m. Mauser magazine rifle. The bullet was sharp-nosed (partly of the heavy-headed pattern of 1890). The number of cartridges carried per rifle was 120 on the man, 48 in the first line transport, and 131 in the park. Part of the infantry were armed with Henry-Martini rifles. The bayonet was long-bladed.

The infantry equipment included a small shovel.

The field artillery gun was the Krupp 7·5-c.m. shielded quick-firer.

Of machine guns they had 20 Maxims and 45 old Gatlings.

The cavalry were armed with Mauser carbines (9·5 m.m.); the rest of the troops were armed like infantry.

Training.

The military education of the troops of the garrison was bad. The Nizam Infantry knew how to fire at a standing target only, the Redif had learnt nothing about shooting, and many of them now saw a rifle for the first time in their lives. In order to reduce their shortcomings in shooting the Turks made use of a method, called by the Bulgarians "parallel firing," of so shaping the parapet that if a rifle is laid on it and fired without aiming, the bullet will travel parallel to the ground in front. The Bulgarians admitted that this had some effect in improving accuracy of fire, but generally the shooting of the Turks was very bad.

Only the best of the Nizams had learnt the use of the shovel, and applied it during their sorties.

The firing of the artillery was little better than that of the infantry. In measuring ranges they were more successful, but they knew nothing whatever about the timing of shrapnel, and consequently their shells burst either very high or on graze.

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Besides this the Turks had a habit, once the range was found, of not changing it, even though the target moved, and often continued firing at nothing. The shooting of the heavy artillery was no better than that of the field guns.

Moral.

The spirit of the garrison during the first period (up to the armistice) was kept up by the false information published in orders by Shukri-Pasha, informing inhabitants and garrison of brilliant Turkish victories or announcing retirements in anticipation of premeditated strategic combinations. But after the armistice, when the truth was known to all, it fell and repeated desertions occurred. The permission given for the free passage of Bulgarian supplies for Chatalja through the fortress had an especially depressing effect on the defenders. The Christians who were forcibly impressed into the ranks did not contribute to the *moral* of the garrison.

The Artillery Armament.

According to the information which had been collected by the Bulgarians up to 1911, the Turks intended to place in the fortress 192 guns of heavy calibres, and 320 to 325 field guns. Actually, it was found that the number was greater, exceeding 600.

On the positions, judging from the Bulgarian map, there were 30 batteries of heavy guns and 39 of field guns (without teams). In addition to this there were 72 guns (10·5 c.m., 12 c.m. and 15 c.m.) which at first were equipped with teams, but later lost their horses from want of forage.

The greater part of the guns were Krupp's, of both old and new patterns. By calibres and types the fortress artillery was divided in the following categories :—

8·7-c.m. field non-quick-firing guns	.. ..	39 batteries.
10·5 to 12 and 15-c.m. siege guns	.. ..	14 ,,
15-c.m. on overbank mountings with all-round fire (marked " Krupp—67 g ")	.. ..	13 ,,
15, 18 and 21-c.m. mortars on overbank mountings		3 ,,

The howitzers were of new types, 10·5, 12, and 15 c.m., included in the 72 which were equipped with teams.

Besides these, quick-firing field batteries were also included in artillery armament.

The 10·5-c.m. guns had the longest range (12,000 yards). The 21-c.m. mortars had the greatest explosive effect, making in clayey ground a crater nearly 15 ft. in diameter.

The shells were common (with powder), and high explosive. The shrapnel were of ordinary type, and there were also some star-shell, burning on burst for 2 to 5 seconds with a blue flame. Apparently there was abundance of military stores, for the Turks fired very extravagantly during the siege, replying with ten to each single Bulgarian shot.

The 10·5-c.m. long-range guns equipped with teams were of special value to the Turks; they appeared quickly in the most important sections and did great hurt to the attack. From the reports of eye-witnesses these guns were effective with shrapnel against aeroplanes, but besides these, as the writer was informed by the Bulgarian Headquarters, the Turks appear to have had two Krupp guns of special construction for firing at aeroplanes.

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Communication Roads.—The fortress was well supplied with these, especially in the North-West Front. The provision was worst in the East Front, where there was no metalled road—the main roads leading to Constantinople and to the north were only metalled in places—and the communication between the forts was carried out on an unmetalled road which ran along the crest, in places even in front of the forts. Unmetalled roads also ran to the advanced positions, and these, in rainy weather, owing to the clayey soil, became soft and difficult to traverse. Communications.

A Décauville narrow-gauge tramway was laid in the fortress, well concealed in folds of the ground, and well distributed. There were circumferential and radial lines. The rolling stock included five engines, of which three were small, and about 200 wagons of various types. There were also a few motor lorries.

The communication between the various sectors was carried out by bridges. There were between the North-West and the North-East Sectors, across the Tunja, six permanent bridges, of which two were of wood. Avoiding the town two stone and two timber bridges could be used. Between the North-West and North-East and the South Sector there was a single stone bridge, spanning the Tunja and Maritza, on the Adrianople-Karagach high road. Communication between the West and South Sectors could be carried out by the railway bridge, on which a timber roadway had been laid. Between the West and the North-West Sectors there was no direct communication.

In addition the Turks allotted to the fortress 118 iron pontoons with all the superstructure, etc., for making a bridge, but none was made, and the pontoons remained unused during the whole siege.

The want of good communication between the South and East Sectors prevented the Commandant manœuvring with his reserve, which had a disastrous result during the assault on the fortress by the troops of the Allies.

In Fort Hedirlik there was installed a wireless telegraph which maintained communication with Constantinople throughout the siege. In the same fort was the central telephone station, connected by underground cables with all the important works in which instruments were erected, 26 in number. The works were also connected with one another by telephones. There were also many field telephones. Telegraphs and Telephones.

Victualling Stores.—The fortress was abundantly provided with supplies. All the rumours of shortness of food were spread by fugitives from the fortress, generally by Christians, who actually did starve, as Shukri-Pasha economized the supplies for the sake of the troops. It was only due to widespread help which was organized by the Russian Consul, M. Klimenko, that the Christian population survived the siege. Supplies.

The grain, of which there was a large quantity, was ground in the large flour mills at Karagach. The Bulgarians endeavoured to demolish these mills by artillery fire, but failed to do so. A great quantity of cattle had been collected from the neighbourhood (15,000 head of cattle and 50,000 sheep).

By November all the stores of salt, sugar, kerosene oil, firewood (though many of the groves remained untouched) and hay for the horses had been expended. There remained no food for the horses, but the

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soldiers would not eat horseflesh, and so it was arranged with the tants to exchange it for that of horned cattle.

The soldiers received 1 lb. of bread daily. Later on the ra reduced, probably in expectation of a long siege. There was of water, but it was necessary to drink river water, as the towi had been cut off by the Bulgarians.

Balloons. *Subsidiary Means of Defence.*—There was one *captive ba* German make, with the help of which the Turks regulated the their batteries, sometimes successfully.

Searchlights. Three *searchlights*, one of which was sited at first in the work l Tepe, and later in Shaitan-Tarla. Another was on the South and the third on one of the minarets of the mosque of Sultan Seli

Engineer Stores. *Materials for Obstacles and Blindages.*—Barbed wire. Metal s 7·2 and 5·0 ft. in length. Timber stakes suitable for abattis. round sheets of corrugated iron for blindages, of various sizes. of timber, beams, posts and poles.

In addition to this the Commandant had at his disposal the w town, in which he could obtain bricks, beams, planks, etc., in enorm quantities. He could also have used the rails from the Sop Constantinople line, by demolishing the portion of it within the fort area.

Recapitulation. In recapitulation of the contents of this chapter it may be deci that Adrianople in 1912 was not a *fortress* of modern type, j judging by the North-West Sector the ideas embodied in the lat project are *modern German views*, which might have been materi ized in the course of several years. The positions were naturally stro and, generally (except on the East Front), well satisfied the tactic problem, as defensive positions.

Care was displayed in the development of communications, but thi was not carried as far as the provision of bridges ; great attention ha been paid to the fortress artillery, and yet it is impossible to allow tha this problem was satisfactorily settled.

Attention had not been fully turned to the organization of the strong points for close fighting. The " Forts " (if one may so name them) were either utterly out of date, or only half-finished. The infantry positions were only field rifle trenches, not always of full profile and without overhead cover. It would follow that as the temporary bat- teries fulfilled their object with greater success than the quite useless concrete batteries, the material and labour expended on the latter would have been better spent on the better organization of the infantry positions.

The garrison though large was badly trained, the artillery strong but badly sited, and at the head was a man irresolute and weak in character.

In such a case *an attack by assault*, with effective support from heavy artillery, and generally well organized, was bound to be crowned with success ; this by no means demolishes the theories of fortress warfare (as is the opinion of some authorities), but was evidently *in the given circumstances* the *normal method* of capturing the fortress.

F. E. G. SKEY.

(*To be continued*).

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REVIEWS.

BUILDING CONSTRUCTION DRAWING (PART I.).

By R. B. EATON.—(Published by E. & F. N. Spon. 1s. 6d. net.).

THIS book which contains 26 plates of building construction details is a primer for students. The drawings are clear and bold and give examples of work which is met with day by day, but the lettering and figuring is rather crude to place before a beginner. There are concise specifications appended to many of the drawings which should prove very helpful to the student.

FLYING; SOME PRACTICAL EXPERIENCES.

By GUSTAV HAMEL and CHARLES C. TURNER.—(8vo. Messrs. Longmans, Green & Co., 39, Paternoster Row. Price 12s. 6d.).

MR. GUSTAV HAMEL and Mr. Charles C. Turner have presented the world with a work which will come as something of a surprise to those who are fortunate enough to open its pages. As the authors remark—"Many books have been written on the history and on the theory of mechanical flight; practical flying has been comparatively neglected"; but the reviewer, with a bookshelf full of works on mechanical flight, could scarcely avoid a feeling of reluctance to embark again upon the perusal of a subject which, notwithstanding the prefatory remarks of the authors, he might not unreasonably consider had been sufficiently written about for the present, and perhaps for some time to come. But having actually taken the plunge—or, rather, taken the book in hand, it was indeed difficult to lay it down again; it is a veritable mine of practical information, about every possible aspect of mechanical flight, written by men who are well qualified from their own experience or performances, to write upon the subject of practical flying; the book is profusely and beautifully illustrated and printed in comfortable-sized type; the subject matter is well arranged and logically divided under suitable headings in the list of contents, while a capital alphabetical index makes reference easy.

The chapter on "Accidents and their Prevention" is deeply interesting, showing as it does how very seldom an accident can be termed to have been unavoidable. "By the exercise of common prudence by manufacturers, mechanics, and aviators, the number of flying accidents

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could be immediately diminished . . . every pilot could relate, out of his experience, a number of what might have been serious incidents caused by small and absurd oversights. Yet the lesson never seems to be learned ; pilots are incredibly careless and casual, and they leave far too much to their mechanics."

In the taking of precautions the late Mr. S. F. Cody gave a good example, " he always bound his petrol tap, and locked every bolt of his engine, by drilling a hole and binding them with wire." In the chapter on the " Future of Flying " we read : " In spite of the loss of life there is a constantly increasing accession to the number of flyers, so that each year sees the total enormously enlarged. What is far more important is the fact that each year, eminent scientific men and engineers are joining in the study of the problems of flight, in the full realization that aerial navigation is no mere dream, and is not merely a means of play, but serious business that must have a profound effect upon human interests."

It is interesting to note that the authors suggest development " of machines that will fly with their engines working reliably at a very small proportion of their maximum power thus rendering them far less liable to break down ; of machines with variable wing area and angle ; of machines that will land at very low speed." The difficulties in regard to " variable wing area and angle " are generally realized, but it has only recently been established by Dr. Hankin that the variation of angle is actually practised by birds, through the rotation of the wing pinion, which adds greatly to the interest of mechanical evolution along the same lines.

There is a chapter on wireless for aeroplanes, with notes contributed by Marconi ; and also a chapter on the medical aspect of aviation by Y. Elrick Alder, F.R.C.S., which should be studied carefully by all who fly or contemplate flying.

F. G. STONE,
Brig.-General.

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NOTICES OF MAGAZINES.

ENGINEERING NEWS.

February 5th and March 12th, 1914.

THE TESTING OF SAND FOR USE IN CONCRETE.

This article gives detailed instructions for taking samples so that they may be truly representative; instructions for carrying out laboratory tests, with data and measurements required; computations from the data collected and interpretation of results. The details of the tests are too extensive to reproduce and will not admit of condensation. The following notes may, however, prove useful to anyone having to report on the quality of a sand, or to compare various samples. The tests should give 1.—Percentage of moisture in sand as received. This may make considerable difference in long-distance carriage charges. 2.—Percentage of material passing a ¼-in. mesh. This indicates the necessity or otherwise of screening and gives the percentage that can be truly considered as sand for proportioning concrete with broken stone. 3.—Mechanical analysis of sand passing a ¼-in. mesh. This is done by passing 100 grammes through sieves of the following number of meshes per linear inch, 5, 8, 10, 14, 20, 30, 40, 60, 100, 200. The weight passed gives the percentage directly. The result indicates whether or not the sand is well graded. 4.—Weight per cubic foot of dry sand. 5.—Percentage of voids. 6.—Specific gravity of sand. 7.—Specific gravity of particles: should not be confused with 6. 8.—Percentage of silt. 9.—Combustible matter in silt. 10.—Tensile strength of cement-sand mortar of various proportions at 3, 7, and 28 days. 11.—Resulting volume of mortar yield for various proportions. 12.—Weight per cubic foot of mortar. 13.—Percentage of absorption of mortar. 14.—Compressive strength of mortar after 7 and 28 days. 15.—Permeability of mortar or concrete blocks.

February 19th, 1914.

THE AUTOCLAVE TEST FOR CEMENT.

This method of test, devised by Mr. H. J. Force of the Delaware, Lackawanna and Western Railway, has been the subject of previous articles (June 13th, 1912; January 23rd and July 10th, 1913) and correspondence. A United States patent has been issued covering this method, which is described below.

Briquettes are made as usual and stored in a moist cupboard for 24 hours. Three are then broken in the testing machine. Three others

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are weighed and subjected to boiling under pressure. The pressure must be higher than 50 lbs. per sq. in., and is preferably 285 lbs. per sq. in. as the time required is thereby reduced. The briquettes are placed in a suitable vessel containing water at 70° F., which is then closed and heat applied. It takes about an hour to develop the pressure of 285 lbs. and this is maintained for another hour. When the pressure has been reduced the briquettes are placed in the moist cupboard for half an hour, are weighed and then broken in the testing machine.

The briquettes should be uninjured by the boiling and should show no cracks on the surface; the increase in strength should be at least 25 per cent., and the strength after treatment should be at least 400 lbs. per sq. in.; and the weight should not show an increase of over 1 per cent. Square bars 1 in. × 1 in. × 6 in. treated as above should not increase in length more than ½ per cent. during the test.

Only high-class cement suitable for sound and lasting concrete and of extreme fineness will pass this test. Inferior cements will crumble and disintegrate.

TESTS OF MODERN HIGH-SPEED BRAKES ON FAST PASSENGER TRAINS.

Tests of the new Westinghouse electrically controlled brake were carried out in 1913 on the Pennsylvania Railway. The train consisted of 12 steel passenger cars and a heavy locomotive, weighing in all about 1,000 tons and being about 1,000 ft. long.

Of special interest to structural engineers is the retarding force during stops, which must be allowed for in the design of bridges. The above-mentioned train with the new brake, 150 per cent. braking power and two unflanged brake shoes per wheel produced the following results:—

Speed. m.p.h.	Length of Stop. Feet.	Average Retarding Force. lbs. per ton.
30	200	300
60	1,000	240
80	2,000	214

This force, as far as a bridge is concerned, is distributed according to the wheel loads.

With the new brake the application is simultaneous on all cars regardless of length of train, so that there is an entire absence of shock, and as there is no reduction of train pipe pressure release is quicker. Maximum brake shoe pressure is obtained 2·25 seconds after application.

February 19th and 26th, 1914.

CONCRETE ROADS.

At Chicago, on February 12th, 13th and 14th, there was held the National Conference on Concrete Road Construction. At it reports were presented covering the latest practice in all parts of the country, in connection with this type of construction. Concrete had long been considered an unsuitable material for road construction and even those who first adopted it were sceptical of its success. It is therefore not surprising that the first experiments were failures. Most of the causes of failure are now understood and many successful roads of this material

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have since been made. In its favour it may be said that it is second only to granite blocks in point of durability; with properly selected materials it is less slippery than most other road materials; if a moderately rich mixture is used it is homogeneous and impervious to moisture; it requires but little maintenance; and, if suitable equipment is used, it can compete with any other material in point of cost (in fact, there are few other types of road that can be laid as cheaply).

Material and Workmanship.—Both sand and coarse aggregate may consist of the same material, which should be clean, hard, durable granite, trap, conglomerate, gravel or other hard rock, free from dust, loam or vegetable matter. Sand, as defined, is such that it will pass a ¼-in. sieve, of which not more than 10 per cent. will pass a 50-mesh sieve and 2 per cent. a 100-mesh per linear inch sieve. Coarse aggregate is such that it will be retained on a screen with ⅜-in. openings and will pass 1½-in. and 2-in. screens for one and two-course work respectively. For two-course work the top course aggregate should pass a ⅜-in. mesh and be retained on a ¼-in. mesh. Natural gravels and crusher run stone should be screened to above standard and remixed in the proper proportions. For one-course work the mixing proportions are 1 : 2 : 4. For two-course work the proportions are 1 : 2½ : 5 for the base and 1 : 2 for the top coat. The best results, as regards mixing, have been obtained with concrete of medium consistency. No more water should be used than is necessary to allow the correct surface form to be obtained by striking with a template. The surface should be finished with a wooden float. It should be then covered with sacking, sawdust or other suitable material and kept well wetted for seven days.

Drainage.—Efficient drainage of the foundation is a necessity. If the concrete is well made no water will penetrate it and one's whole attention should be devoted to preventing penetration of water under the edges of the slab. If sufficient attention is paid to drainage an elaborate broken stone foundation does not appear to be necessary. The soil should be hardened with a steam roller, great care being taken to avoid soft spots. On clay soils, naturally soft, reinforcement in the concrete may be required in addition to drainage.

Design.—There is a growing tendency to make the foundation level or slightly dished, as this, in conjunction with crowning of the upper surface, gives a slab thicker in the centre than at the edges. For roadways up to 16 ft. wide, on soils more or less porous, taking loads up to 6 tons, the centre should be 7 in. thick and the edges 5 in. thick. For the above road on clay soil, or for wider roads, or for loads up to 10 tons the centre should be 8 in. thick and the edges 6 in.; reinforcement (¼ to ½ lb. per sq. ft.), placed 2 in. below the surface, will generally be required and is an economy. The road should be laid in sections not exceeding 16 ft. in length and the joints filled with a bituminous compound. On country roads where there is no curb to provide lateral support for the edge of the concrete a shoulder of bituminous macadam should be provided. The crown used varies from ⅛ in. to ¼ in. per foot width of road and experience indicates that even smaller proportions can be used with success.

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Expansion and Contraction.—Many measurements of concrete roads have been made at all seasons of the year with instruments reading to 1/100 of a millimetre. The results showed that concrete, exposed to the weather, behaved like wood, in that the absorption of moisture caused more expansion than a rise of temperature of 90° F. On drying out the concrete returned to its original length. The greatest length was in April, when the temperature was about average value, and the least length in August, when the temperature was highest, with more or less uniform change between. In general the length varied directly with precipitation and melting of snow.

W. G. TYRRELL.

REVUE MILITAIRE.

September, 1913.

The Army Estimates of Great Britain for 1913–14 are discussed. A *résumé* of the Siamese Army is given.

October, 1913.

FOREIGN INTELLIGENCE.

United States of America.—The American flying corps appears to be still rudimentary, of 18 officers only 9 hold flying certificates. There are flying stations at San-Diego, 10 aeroplanes; Texas City, 2 aeroplanes; Fort Leavenworth, 1 aeroplane; Manila, 2 aeroplanes; Honolulu, 1 aeroplane. All the machines are biplanes.

November, 1913.

THE FINANCIAL PROVISION OF THE NEW GERMAN ARMY LAW.

It is pointed out that the net effect of the law is to bring into being the provisions of the 1912 law within 18 months instead of within 4 years. The result is shown very clearly by means of a table.

THE DANISH ARMY IN 1913.

The army is organized in 2 commands to the east and west of the Great Belt. The former consists of 3 divisions, the latter of a mixed brigade. There is a small garrison on the island of Bornholm, and fortress troops at Copenhagen. On a war footing the army is 69,000 strong; its equipment is inferior.

December, 1913.

THE JAPANESE ARMY.

The remarkable efforts made, since the Russo-Japanese War, by the Japanese War Ministry, by which the army has been almost doubled, are discussed. The original intention was to bring the army up to a strength of 25 field, and a like number of reserve divisions, by a programme distributed over a number of years. The programme is, however, at present in abeyance as the result of popular agitation.

E.R.

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Revue Militaire Suisse.

March, 1914.

Self-Instruction for Young Officers outside the Service.

By Major Verrey.—This article contains valuable hints, intended for officers of a Militia army, for acquiring a good knowledge of their profession by study at home. It should be interesting to officers of the Territorial army.

Revolver Practice for Officers.

A lament, from 1st Lieut. John F. Revilliod de Budé, of the Landwehr Artillery, that officers take so little interest in revolver shooting. He calls upon the government to make compulsory an annual course of revolver shooting for all ranks armed with that weapon, and would entirely abolish the sword for officers, except for parade purposes in peace time.

The Bridging Regulations.

By L.—After preliminary remarks as to the absolute necessity for good bridge equipment in the Swiss Army, the writer proceeds to give a short summary of the new regulations. In the first place they are "regulations," and not "instructions" as hitherto. The equipment is not altered. The old instructions did not enter upon the field of tactics, but the new Chapter VI., describing the crossing of a river in face of the enemy, is essentially tactical. The position of the bridge having been determined by tactical considerations, troops must first be passed over to secure the further bank. This operation will probably take place at night or early dawn, and at a different place from that selected for the bridge.

The pontoons are removed from the wagons when the latter can advance no further under cover, and the troops detailed for the attack of the further bank are instructed in embarking and disembarking. The pontoons are then carried to the bank, and two sections joined together to form a boat, which will hold 16 to 20 soldiers in addition to from four to six boatmen. The boats must all be launched at a fixed time, and as rapidly as possible, since signalling will be difficult. Meanwhile the troops intended to cover the crossing, infantry and artillery, will have taken up their positions.

The attacking troops immediately embark, rifles unloaded, bayonets fixed. During the passage the men remain seated till ordered to rise, no reply being made to the enemy's fire. The landing is the critical moment—probably the best method will be to throw grenades, charge with the bayonet and clear the bank. Beyond this the first troops will not advance for the present. The boats then return, and continue to transport the attacking force.

Orders are required (1) for the troops attacking, (2) for the boatmen of the bridging troops. The regulations do not lay down any strengths for these. At Dietekon, Massena transported 600 men at each crossing, and a brigade—one-third of his total strength—altogether, using 37 requisitioned boats, and two bridging companies. For a brigade nearly two Swiss Army bridging trains would be required. (3) for the covering

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infantry—probably a battalion, (4) for the covering artillery—at Dietekon, Massena concentrated 28 guns, a strong force for that period, (5) for the main body, which will have to cross later by the bridge, and (6) for the construction of the bridge itself. At Dietekon the actual bridge equipment was brought up as soon as the first 600 men had been ferried over, and the remainder of the attacking troops were conveyed in the requisitioned boats. The bridge was commenced at 5 a.m. and completed by 7.30 a.m., by which hour 8,000 men had been ferried across. By 9 a.m. the whole of Lorge's Division (16,000 men) was on the further bank. The width of the river was 90 m.—16 pontoons.

The army bridging train will suffice for a bridge 158·4 m. long, or 18 boats carrying 360 infantry. The six divisional trains will suffice for a second bridge of the same length.

The old instructions only laid down a bridge 3 m. wide for all troops and vehicles, and a footbridge 1·5 m. wide for infantry in file. The new regulations deal with the construction of three footbridges, 1·5 m. for infantry in file and single troopers, 2·25 m. for columns of march, single troopers or light vehicles without their teams, and a column bridge 3 m. wide, for infantry in column of route, cavalry in file and vehicles up to 3,000 k.g. (3 tons nearly) in weight. For this seven roadbearers must be used instead of five. Also a heavy bridge for 12-c.m. guns on their carriages, and motor vehicles up to 6,000 k.g. This bridge necessitates a special strengthening of the supports, of roadbearers, and double decking.

Another innovation is the carrying of a steel cable, to stretch across the river to moor the pontoons to, where the anchorage is bad.

THE ORGANIZATION OF THE INFANTRY TRAIN.

By Capt. Gouzy, Officer of Train, 4th Infantry Brigade.—Each battalion has a mounted corporal of the train, and an officer of the train (Lieut. or Capt.) is attached to the Regimental Headquarters, also another officer (Capt. or Major) to Brigade Headquarters. A weak point in the organization is that a Quartermaster is often placed in command of sections of the train. He has too many other matters to attend to for it to be possible for him to be always with his column, and even if he is present he generally knows little about horses, and the details of their harness, watering and feeding, dressing of wounds, etc. If no officer of the train can be spared for such a section the Quartermaster ought at least to have a N.C.O. of the train under his orders to superintend these essentials.

The rank and file used to be trained by the artillery, but are now distributed to all arms. This does not tend to uniformity in their training, and many commanding officers cannot take much interest in them, or use them as orderlies and for barrack fatigues. This is to be regretted. The writer would like to see a return to the old system, or some modification of it, and this would probably be financially sound, leading to better care being taken of the horses. Officers should be given some executive as well as departmental control over their men, horses, and equipment generally.

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April, 1914.

THE SECTION COMMANDER.

By Lieut. Turin.—The writer sets out to define the qualities necessary to produce the ideal section commander, and comes to the conclusion that character is the basis of all. He must also be endowed with a thorough military spirit, and keep war, and the preparation for it of himself and his men, constantly in view. The success of the Japanese was due in a great measure to their true military instinct, the failure of the Russians to their lack of this attribute. Every soldier must be prepared to sacrifice himself if necessary to save his comrades; it is the good section commander who, by precept and example, can best imbue his men with this spirit.

THE OPERATIONS OF THE SERVIAN ARMY.

By A.—This sketch is continued from the close of the Battle of Kumanovo up to the Battle of Monastir, of which there is a map. The march of the third army to Durazzo is also shortly traced.

THE MICHOUD ELECTRO-MECHANICAL TARGET.

When using this appliance the approximate position of the shot is shown upon an indicator at the firing point. The target is constructed of as many metal rings as there are different points to be scored in the competition (figure targets are divided horizontally into three sections—head, body, and legs) and is fixed in a frame. Behind the target are hung from the frame four pendula. On a shot striking one of the annular rings, this ring is slightly forced back against one or more of the pendula, which by their movement complete an electric circuit through a battery and cable to the indicator. The ring is then returned by springs to its normal position. The indicator is a miniature target, divided by lines into eight sectors (line high, high right, right, low right, etc.), and has under it a dial showing the value of the hit. A hit on the edges of two rings causes two figures to appear. High left, high right, low right, low left are indicated by the letters A, B, C, D in the respective sectors; hits in the intermediate sectors are indicated by two letters appearing, one on each side of the sector hit. The apparatus is said to be very strong and durable, accurate, unaffected by weather, and to be superior to marking by hand, but as it cannot record misses a marker at the target is required to show the direction of a miss.

STUDY OF MOTORS FOR AVIATION.

By Major Le Royer.—Progress is traced from the four-cylinder motor through those with eight cylinders, and cylinders arranged like the points of a star, to rotatory motors. The latter obviate many of the disadvantages of the earlier patterns, and tend to greater lightness of all parts of the machinery for the same horse-power. They however consume more fuel. The writer considers the Rhone engine the best hitherto constructed. When, however, a long flight is projected without a halt the engine with fixed cylinders has the advantage owing to the difficulty of carrying sufficient fuel for the rotatory engines.

A.R.R.

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RIVISTA DI ARTIGLIERIA E GENIO.

January, 1914.

THE ARMAMENT AND THE OFFENSIVE EMPLOYMENT OF AIRSHIPS.

There is generally a good deal of uncertainty as to the best way of employing airships for offensive purposes, and for many reasons this can hardly be wondered at since experience is lacking in their intrinsic offensive capacity, and the method by which this offensive capacity can be rendered useful in the operations of war.

The first results to be obtained from such experience may be divided under three heads, viz. :—

I. *Armaments.*—How ought airships—dirigibles and aeroplanes—be made and armed so as to be best fitted for employment?

II. *Offensive Action.*—How can they best be used for means of offence?

III. *General Offensive Employment.*—How can the offensive action of the airships can be best utilized in a general action?

Armaments.

The armaments of airships is really regulated by two conditions (1) the specific weight of the different kinds of ammunition, and (2) the natural limited capacity that the airships may possess for carrying useful loads.

At the first glance it would appear that the airship possesses a very secure and efficacious method of offence, but an examination of the question shows that this is not so. Its utility is restricted both by its having to carry heavy loads, such as ammunition in large quantities, and also by the difficulty of determining the right moment for discharging a projectile, when travelling at great speed and under indeterminate atmospheric fluctuations.

When studying therefore the armament of airships the following two special points have to be considered, viz. :—(*a*) that the material should be as light and effective as possible ; and (*b*) that the material be utilized in the best possible way.

The solution of this problem has of course been much assisted by the discovery of light metals of great resistance, and of explosives of great power which can be used with ease and safety. On the other hand one must remember that the ammunition when it consists of large and heavy projectiles, cannot (in a proper sense of the word) be *discharged* from airships, but that it can only be dropped, as the car of a dirigible would not support the weight and the shock necessary for firing large projectiles with considerable initial velocity. Airships should therefore give up all idea of heavy artillery as being unsuitable.

Projectiles designed for dropping only can be arranged more easily and with greater efficacy and are of less specific weight than artillery projectiles, which is of course a great advantage for use in airships.

Light ammunition (as for example that destined for moving objects, or against lightly resisting targets such as the enemy's airships) may be discharged from machine guns or small cannon with considerable initial velocity. Even in the case of dropping fire it is advantageous if possible to use some means of propulsion as it obviates the necessity

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of passing exactly over the target. But the need of using heavy mechanism to allow this to be done, counterbalances the advantage gained. It may safely be assumed therefore that heavy projectiles should be used for dropping against resisting targets, and small projectiles should be available for discharge against aerial targets. It must not be forgotten that in firing against moving objects with small projectiles (as for example those discharged from mitrailleuses) the effect is not great owing to the bullets striking at a great angle.

The armament for airships may be treated generally under three headings :—(*a*). Dropping fire with heavy and powerful projectiles against resisting targets ; (*b*), dropping fire with bursting projectiles and bullets against moving objects ; (*c*), discharging fire with small projectiles against special targets and particularly against aerial targets.

(*a*). *Dropping Fire with Powerful Projectiles against Resisting Targets.* —Destructive action against resisting targets requires the use of large and heavy charges. Ordinary artillery, and especially field artillery, is limited in the employment of these heavy projectiles both because of their weight and also because guns that are designed to fire them are much more difficult to manœuvre. The airship, however, is not affected to the same extent. In this respect it has a very great and special advantage over artillery, and one of the principal reasons for the offensive action of airships is that they can carry greater explosive charges for destructive action than the artillery. Siege guns can use projectiles of the great weight of 164 k.g. with charges of 31 k.g. ; ordinary artillery, including heavy artillery, can use projectiles of 40 to 45 k.g., with charges of 8 to 10 kilogrammes. A dirigible—even a small one—can carry projectiles of 100 kilogrammes, containing half a quintal of explosive. Besides this advantage, the airship can use projectiles of a shape and size better fitted for the explosive charge, whilst the artillery require their size and weight to be adapted to the bore and grooving of the guns, independently of their explosive effect. For the ammunition for airships for dropping fire against resisting targets the following types are recommended :—

(*a*). Great shells of 100 to 150 k.g. with 25 to 40 k.g. of explosive to be used against targets of the greatest resistance.

(*b*). Great torpedo shells of 100 to 150 k.g. with 40 to 60 k.g. of explosive of less diameter than the former for targets of not very great resistance.

(*c*). Medium-sized shells of 50 to 60 k.g. with 20 to 25 k.g. of explosive for targets of medium resistance.

(*d*). Small shells of 15 to 20 k.g. with 6 to 8 k.g. of explosive for special fire against targets of secondary importance and of small resistance.

The small dirigibles can only use the medium-sized and small shells. The mechanism for dropping the shells is simple. The shells themselves can be arranged in a convenient position in the car, and dropped through a tube or other system for guiding the commencement of the fall. The use of these projectiles on board is safe and simple provided that the airship is properly steered and that the projectile is dropped at the right moment.

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Dropping Fire with Shrapnel Shells against Moving Objects.—To strike moving targets is an important, but not the principal *rôle* of airships. At a height of 1,000 to 1,200 metres it is difficult to see moving objects, and the measures adopted for concealing the troops reduce the offensive action of airships. The ground seen from a height of beyond 1,000 metres assumes a characteristic aspect in which all the distances are shortened and all the secondary details disappear. It becomes, as it were, minute and fading away in the vast horizon. Infantry is only discernible in mass assuming the appearance of a narrow track in the road. Cavalry and artillery have a slightly more consistent appearance than the infantry, but are surrounded by a string of dust which conceals the main body and the rear of the column. Fieldworks, siege works, trenches, batteries and redoubts are usually more visible, but they also appear as small furrows, with thin shadowy lines.

Discharging Fire with Small Projectiles against Special Targets particularly against Aerial Targets.—The automatic weapons of small calibre, mitrailleuses, etc., have now attained a high grade of simplicity and lightness, and work with security and rapidity. These are considerations of much value in the armament of airships. Their weight, indeed, is very small, scarcely more than a dozen kilogrammes for mitrailleuses of small calibre, up to 80 to 100 k.g. for small cannon of 25 to 30 m.m.; their rapidity of fire is wonderful, rendering them capable of developing a great fire action in a short time; and their automatic action works so well that there is less recoil, with the advantage of security against fires. Mitrailleuses with the calibres of rifles are now reported to be installed in the monoplanes and biplanes, and in the cars of dirigibles; mitrailleuses of greater calibre are carried in the upper part of certain dirigibles, viz., Zeppelin.*

E. T. THACKERAY.

* Recently at the fifth exhibition of locomotives at Paris, a Hotchkiss mitrailleuse was exhibited in the upper portion of the car of the dirigible "Astra" of 23,000 m^3, built for the French and Russian Armies.

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CORRESPONDENCE.

NOTES ON R.E. WORK AT SIERRA LEONE.

DEAR SIR,

With reference to the article on the above subject which appeared in the *R.E. Journal* of May, two points suggest observations, founded on my experience as O.C.R.E. in the Colony in 1909–10–11.

1. *Eaves Gutters.*—In 1908 the eaves gutters at Tower Hill were removed as they were said to harbour mosquitoes. It was found that in their absence the heavy rain streaming down the sides of the buildings did serious damage and caused great inconvenience to the occupants. The gutters were accordingly replaced.

Eaves gutters must be kept clean and constantly inspected to see that they do not sag and furnish breeding places for mosquitoes.

2. Joinery made with locally purchased timber which has seasoned in the Colony is much better, and in the long run cheaper, than joinery made at home.

3. As regards cost of work, a great deal depends on the chasing power of officers and M.F.W.'s. To get work done cheaply both officers and M.F.W.'s must be physically fit.

4. This brings up the most important point of all, viz., how to keep Europeans fit in the unhealthy climate.

I found that moderation in all things, and as much hard work and walking as possible, kept our men the most healthy troops in the garrison. (Sleep and sloth are even more deadly to health than the mosquito).

I hope that these notes may be of some use to future R.E. inhabitants of Sierra Leone.

G. WALKER, *Major, R.E.*

Curragh Camp, 4th May, 1914.

The Editor, *R.E. Journal.*

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BOOKS RECEIVED.

WIRELESS TELEGRAPHY. A Handbook for the Use of Operators and Students. 154 illustrations. By W. H. Marchant. 1914. Price 5s. net. Whittaker & Co., 2, White Hart Street, Paternoster Square, London, E.C.

HISTORIQUE DE LA GUERRE SOUTERRAINE. Par A. Genez, capitaine du génie. Un volume in-8 de 297 pages, avec 37 figures et 13 planches hors texte. Prix 5 fr. Berger-Levrault, éditeurs, 5-7, rue des Beaux-Arts, Paris.

LA FORTIFICATION DANS LA GUERRE NAPOLÉONIENNE. Par le Général Camon. Un volume in-8, avec 15 figures. Prix 2 fr. Berger-Levrault, éditeurs, 5-7, rue des Beaux-Arts, Paris.

THE CHANGES IN THE CLIMATE. By Major R. A. Marriott, D.S.O., late Royal Marine Artillery. 1914. Price, paper wrapper, 1s. 6d.; cloth binding, 2s. 6d. E. Marlborough & Co., 51, Old Bailey, London, E.C.

TECHNICAL WORDS AND PHRASES. An English-German and German-English Dictionary. Cloth, 2s. 6d.; leather, 3s. 6d. 1913. E. Marlborough & Co, 51, Old Bailey, E.C.

THE MILITARY POLICY AND INSTITUTIONS OF THE BRITISH EMPIRE. An Essay by C. W. Pasley, Captain in the Corps of Royal Engineers. Edited in the Light of the Science of Organization by Colonel B. R. Ward, R.E. 5th edition. 1914. Wm. Clowes & Son, Ltd., 31, Haymarket, London, S.W.

AN ELEMENTARY TREATISE ON THE CALCULUS FOR ENGINEERING STUDENTS. With numerous Examples and Problems worked out. By John Graham, B.A., B E. 1914. 4th edition. 116 illustrations. Cloth. Price, 5s.; by post 4d. extra. E. & F. Spon, 57, Haymarket, London, S.W.

BUILDING CONSTRUCTION DRAWING. A Class Book for the Elementary Student and Artisan. Part I. 26 plates. By Richard B. Eaton. 1914. Price, 1s. 6d.; post 2d. extra. E. & F. Spon, Ltd., 57, Haymarket, London, S.W.

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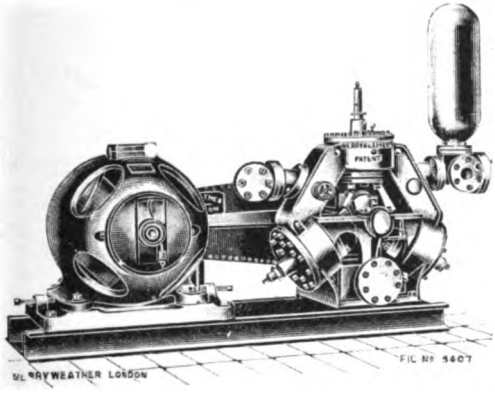

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